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TRANSACTIONS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA,

FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XIV.—NEW SERIES.

PART III.

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ARTICLE IV.—*The Arawak Language of Guiana in its Linguistic and Ethnological Relations. By D. G. Brinton, M. D.* 427

ARTICLE V.—*Contribution to the Ichthyology of the Lesser Antilles. By Edward D. Cope, A. M.* 445

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DECEMBER,
1871.

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5. The order in which papers are read shall determine their places in the Transactions, unless otherwise ordered by the Society; priority of date giving priority of location.

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ARTICLE III.

SMELTING PROCESSES AT FREIBERG.

BY PERSIFOR FRAZER, JR.

Read June 17th, 1870.

THE present chart and text form part of a work intended to accompany an application for examination in Metallurgy at Freiberg, Saxony. The text follows the order of a preliminary course of lectures on the Freiberg Smelting Works, delivered at the works themselves, every day during the month of August, by Herrn Hütten—Assistant Marhold, and illustrated by personally examining the things spoken of. The plan of the chart is entirely original, and its execution may be said to be a crude and imperfect attempt to portray what actually takes place at the Smelting Works; and, while exhibiting the mutual relations of the different processes, so to separate them from each other, that they and the constituents entering into every one of them may be traced to their origins and applications. To do this it was necessary to condense the area of the chart as much as possible in order to allow the whole to be seen at a glance, and on the other hand some new symbolical method was requisite which should better conform in system to the real sequence of operations. The former plan, adopted by Lorenz and others in the "trees," &c., seems to have several objections. In the first place, it takes up a much larger space, and renders it more difficult to get a general view of the whole cycle. Then, it permits only imperfectly the processes to be followed backwards (synthetically or from educts and products to ores and reagents), because these educts and products being separated and scattered over the whole text of the "tree," are not so readily found, and when found must be traced back through six or seven disconnected descriptions of different substances advancing in complexity of chemical composition. The products of any particular process are, by this plan, necessarily strung out in horizontal

lines across a broad sheet, while the vertical lines represent more or less the advance of the substance either from simple to complex (synthetical—educt to ore) or complex to simple (analytical—ore to educt). This is the principle involved in this order of arrangement, but we shall see that it is but partially realized in fact.

This tree commences by describing in two long lines the kinds of ore brought to the lead process, which it makes the inception of all other processes.*

A long horizontal line is made to extend over the several products which result from this lead process, viz.: Lead slag—Raw lead—Lead Matt—Lead Speiss—Furnace ends—Furnace fume—Dust.

The Lead Matt is here considered the important product, and an arrow from this, points downward to the next horizontal line, which includes six products, and takes up as much space as the one above for the lead process. This second line cuts off any direct connection between any other of the seven products of the lead process, and the processes by which it is further treated. As this is repeated about twelve times, it will be apparent that the relations of these substances and processes to, and their dependence upon each other, far from being revealed, are effectually concealed; different substances which belong to the same process being so scattered over the whole sheet as to make a comprehensive view of that process impossible, and the fact that the same substance under different circumstances is treated differently, being only conveyed to the mind by two or three lines of text under the name of the substance.

Thus there are eleven products which, according to Lorenz, are treated in the Lead Matt Process, but those eleven names are so scattered on the sheet from the first line to the last, and from the right to the left, that it would be as easy to see at a glance the philological relations to each other of the words in a Worcester's Dictionary as those of these products.

It has been remarked that Lorenz's plan permits one to follow the processes synthetically, but this is the case only so far as it permits one to follow the *main line* from the educt or product through a *principal* product which has been used in each process up to the ore in which the educt or product was originally contained. What other materials have assisted in the process, and whether any other process may not have given the same product, you are not able to discover. For instance, if it is required to trace the course of raw lead from any particular process, it must be known beforehand where the previous product comes from. To know this, you must know how that product is found, and so on to the end. In other words, you must know exactly what you want to find out. It is

* It should be remarked that this other system does not pretend to deal with the auxiliary operations, such as sulphuric acid manufacture, zinc production, &c.

true that you can follow any product on which you happen to alight, and find out one line of main products through which the ore has been transformed to that particular one, but to understand even what other agencies have had their influence in the formation of the substance, you must consult either the text of the chart (in the few cases where such explanation is given) or some more detailed work on the Freiberg processes; and in addition to this defect it is not always easy when practically the same substance (as Raw Lead, &c.), resulting from different operations, is scattered in a dozen places on the "tree" to find that which is required. Again, it is not easy to follow the processes *analytically* as in their actual sequence, for the reason indicated before, that but one of the many products is selected as the most important in every line, and these lines separate one set of products from the others with which they are mixed for their further treatment. Another objection to it is, that it only mentions the composition of the charges in the most important cases, and leaves those reagents which are not ores, entirely out of consideration; and another, that no other but pyro-chemical processes are given, and not all of these. In the substitute which I propose for this "tree," the attempt has been made to attain to a system which, while it represents the actual sequence and co-sequence of processes, permits an empirical view of these which it requires but little technical information to understand.

SMELTING PROCESSES AT FREIBERG.

The Freiberg smelting processes have for their object the production of silver, lead, and copper (chiefly as blue vitriol), from the ores obtained from the royal Saxon mines; but, outside of these, from other purchased materials and foreign ores (as for example, jewelers' sweepings and American ores), and middle products from previous smelting processes (silver, lead, etc.), but especially copper and gold from the foreign ores. The sulphur which is present in the ores in great quantity is applied as much as possible to the manufacture of sulphuric acid, as also the greater part of the arsenic present in the ores is converted into various products of the arts. White arsenic (arsenious acid), red arsenic (realgar of commerce), yellow arsenic (orpiment of commerce), and black metallic arsenic (so called cobaltum or Fly stone). They have also turned their attention recently, with good result, to the experimental production of zinc from the ores rich in that metal. The percentage of silver in the Freiberg ores comes especially from more or less finely divided silver-glance, polybasite, stephanite, ruby silver ores, and silver Fahlerz. Silver occurs also occasionally though seldom, native, as a wiry, hair-like mass called washed silver, and in combination with arsenic, tellurium and antimony. Lead occurs only as Galena in these ores; copper as copper pyrites, peacock ore, and copper; Fahlerz and the other ores only as combinations with sulphur, never oxidized. The constituents of these ores of secondary importance, which constitute the gangue, are iron pyrites, arsenical pyrites, zinc blende, and earthy substances, such as quartz, lime, fluo spar, heavy spar, and brown spar. A great part of the Freiberg ores contain traces of gold, cobalt, and nickel, but not in paying quantity.

Metallurgical Division of the Ores.

All the ores are divided into

1. Lead Ores.—Ores (without exception argentiferous) which make about one-third ($\frac{1}{3}$) of the entire production of the mines. These are divided again according to their percentage of lead, or the amount of their valueless constituents, into

a) Plumbiferous ores, and
b) Glances (or galenoids).

While the percentage of lead in the former varies between fifteen and twenty-nine per cent., and the percentage of the valueless constituents, such as iron pyrites, arsenical pyrites, zinc blende, and quartz, exceed it; in the latter it goes from thirty per cent. to the highest percentage of lead possible, and the gangue is only represented in small quantity.

Pure Galena (PbS) contains stoechiometrically 86.61 per cent. lead; but it never occurs in nature with so high a percentage of lead. The average percentage amounts to about 40 per cent. lead and 0.15 per cent. Ag.

2. Dürr Ores—These are the real silver ores, which contain no lead and copper (at least in paying quantity), and frequently consist entirely of earthy gangue. As these so often contain arsenical pyrites, iron pyrites, and zinc blende, they are divided according as one or the other of these predominates.

1st. Silicious,
2d. Spathic,
3d. Pyritic,
4th. Blendic,
} Dürr Ores.

The silver in these varies from two-hundredths of a per cent. (0.02 p. c.) several per cent.; so that among them occur the richest ores that are brought to the furnace.

3. Copper Ores.—These are also always argentiferous, but occur *comparatively rarely*. Their percentage of copper varies between 1 per cent. and 10 per cent.; is in the average, however, about 3 per cent. Their constituents of secondary importance are mainly pyritic and blendic. Copper ores with a high percentage of copper are scarcely

ever produced by the Royal Mining Works; but often very rich ores are obtained from foreign countries—chiefly America.

The above three classes of ores are united under the general head of "paid ores," because their purchase is regulated by the established price which the smelting works pay for each metal.

The sulphur and arsenic in these ores are paid for when the material is furnished in lumps, and not pulverized. In such ores the sulphur is paid for when it exceeds 20 per cent., and the arsenic when it exceeds 25 per cent. In contradistinction to the "paid ores" are:

4. The "Reagent Ores."—The purchase of such ores takes place only conditionally on the need which may be felt for them in the different smelting processes, and on the basis of any agreement made between the smelting works and the particular mines furnishing them. All those ores belong to this class, whose percentage of silver varies from one to one and a half hundredths of one per cent. (0.01–0, 0.015 p. c.), provided that a percentage of 15 or more per cent. of lead, or 1 or more per cent. of copper, does not place them among the copper or lead ores.

In these ores also the sulphur and arsenic are paid for under the same conditions as in the "paid ores," except that in arsenious ores the broken form is not desirable. The constituents of these ores are principally iron pyrites, arsenical pyrites, zinc blende, quartz, calcite, etc.; at the same time they always contain small quantities of copper and lead. According to these constituents, these are called pyrito-blendic, silico-pyritic, and silico-blendo-pyritic. To the classes of the reagent ores come those Dürr ores, which contain but little silver (up to 0.04 per cent. when 15 per cent. and upwards is present).

The furnishing of the ores is performed with them either *dry* (1st) dry stamped, (2d) in lumps, as is the case with the reagent ores, or in a moist condition (jigged or washed ore). In the stamped ores, besides a careful mixing, such a size of grain is required, that when it is sifted in a sieve of 675 meshes to the square inch not more than 15 per cent. remains behind.

In wet ores it is required that they be as free as possible from hygroscopic water; that they can be weighed with certainty, and permit the obtaining of a reliable average analysis; and that they be neither in a viscous nor liquid condition.

I. The Lead Process in Cupola Furnaces.

The object of this process is, after previous roasting of the argentiferous Dürr ores, Galenoids, and plumbiferous ores with the proper reagents in a roasting furnace, so to smelt them in a cupola furnace that the silver is extracted by the lead (raw lead), and further that there is produced a combination of different sulphides of the metals (lead matt), and when the ores contain nickel and cobalt, also a combination of arsenides of the metals (lead speiss); on the other hand, the earthy constituents and less easily reducible metal oxides combine to form a slag (lead slag).

Composition of a Charge.

The ores which come to the lead process are:

1. All the lead ores (Galenoids and plumbiferous).
2. All the Dürr ores from 0.1 per cent. Ag. upwards.
3. Copper ores from 0.1 to 0.15 per cent. Ag. upwards, when the percentage of copper does not exceed 6 per cent., because otherwise the raw lead produced would be rendered too impure by the copper, which has a powerful affinity for lead.

The above ores are then sorted and mixed. By sorting is understood a mixing together of those ores which contain, and are treated for the purpose of extracting, one and the same metal, but whose various percentages of this metal are different, and which behave differently in the furnace.

For example, in Freiberg all lead ores are *associated together* and mixed with the Dürr ores, which in their turn are associated together among themselves, as they possess different percentage of silver and different earthy constituents, and also behave differently when smelted. By mixing is understood a mixing of the ores which are to be treated, with the reagents, such as calcite, heavy spar, old slag, or some already existing middle product of the smelting works.

Object of the Composition of the Ores.

The objects of the sorting and mixing, or composition of the ores, are:

1st. In order to obtain a quantity of the metal or product (raw lead, raw matt), which experience proves to be most advantageous, and, what often depends upon this, to procure in the product (*i. e.* raw lead) a certain definite percentage of silver.

2d. In order to obtain a good run, in which the earthy constituents of the ore unite in a fusible slag, which would not be the case if each kind of ore was smelted by itself. The weight of one of these mixtures, which are kept ready in the mixing house, is from 2000 to 3000 centners, of which 80 per cent. are lead ores and 20 per cent. Dürr ores (including copper ores, if such are present). The amount of lead in such a mixture varies between 30 and 40 per cent. of lead; that of silver, 0.15 to 0.18 per cent.

Very rich Dürr ores are excluded from this composition. They are strewed on the floor of the charge room amongst the other ores, as these latter are used up, and from time to time again sorted and mixed, in order to avoid as much as possible mechanical loss. The separate charges are transferred in wheelbarrows from the ore house to the charge house, and dumped in alternate thin layers of lead ore, copper ore, and Dürr ore on the floor. From a heap thus made the mixer takes vertical slices with a shovel, and throws them together in the form of a cone in some other place. To make the mixing still more complete, this operation can be repeated. This mixed mass is pushed from here in iron cars (railroad cars) over the roasting furnace, and dumped there. The dry stamped ores are moistened before this mixing, in order to prevent the raising of too much dust.

II. Roasting or Preparatory Work with the Ores and some Already Formed Products.

The object of roasting is an oxidation of the metals which are combined with sulphur and arsenic, and a volatilization of the above inflammable bodies up to a certain point. A complete volatilization of these materials is not intended. The roasting of the lead process charge can be undertaken either,

1st. In double roast furnaces, or in combined hearth and muffle furnaces.

2d. Of late years principally in "forward-shoveling" roast furnaces.

The real roasting space of the double roasting furnaces, or hearth and muffle furnaces, consists of the hearth and the muffle. The hearth is alongside the fire-place, which latter consists of grate and ash box, and the fire-place is separated from the hearth by a bridge made of bricks. The muffle lies over the hearth, and is entirely separated from it, but is heated by the flame which passes both below and above it. The under hearth is ten feet long and five feet six inches broad (Saxon measure). The roof of the hearth consists of three strong slabs of slate, which rest on three arches, which in turn abut against the longer sides of the furnaces. These slabs form at the same time the floor of the upper hearth or muffle, which, with the exception of three working doors, some air holes, and an opening for the roast gases, is closed on all sides, like a real muffle.

The sole of such a muffle is thirteen feet long and six feet broad. The products of combustion of the stone coal, mingled with the gases arising from roasting these ores, escape from the lower hearth, and pass through a chamber above the muffle, which thus acts as a dust-condensation chamber. At the extremity of the furnace it enters a canal, which connects with a subterranean passage leading to a chimney 150 feet high. The gases from the muffle, on the contrary, escape separately through a long canal to a set of terrace-built condensing chambers, which they traverse, uniting with the other gases behind these chambers, when all go together to the 150 feet chimney.

In these long Canals and Dust condensation chambers (which latter are erected above ground, and provided with a roof of iron plates for the better cooling off of the vapors, but in other respects built of brick), the roast Gases find ample opportunity to deposit all condensable ingredients, especially arsenious-acid ($As_2 O_3$), and the mechanically suspended little particles of ore dust, which otherwise would pass through the chimney and reach the open air, injuring the neighboring vegetation. In the Muldner Smelting works there are 6 such Furnaces in a row, which are to be altered, as 18 already have been, into "Forward-Shoveling" Roast furnaces.

Mode of Procedure in Roasting.

(The strength (the weight) of) a roasting charge for the Lead Process, amounts to ten Centners (100 lbs. Saxon).

The charge enters the muffle by two holes in its roof, from the drying hearth above it. The charge is here brought to a dark cherry-red glow, and remains perfectly in powder form without agglutinating. After 4 or 5 hours roasting, it is reached through the middle working door, and drawn by a rake down through a vertical shoot ending in the sole of the muffle and generally closed by a slab.

It is then roasted in direct contact with the flame of stone-coal. Here the temperature of the hearth is raised until it loses its powdery state and forms larger or smaller lumps. Meantime a fresh charge is brought upon the muffle, receives its preliminary roasting and is raked down upon the hearth as before described.

There are three periods distinguishable in the course of the process.

1) The period of ignition.
2) The period of desulphurization.
3) The period of complete roasting.

In the period of ignition which takes place in the muffle, the ore loses its hygroscopic water. The charge is allowed to lie quietly in the muffle without turning or raking it, until the beginning of the desulphurization, which arises from 1½ to 2 hours after the commencement ("Burning-out" of the Ore).

In the period of desulphurizaton the sulphur and arsenic present in the ore, commence to burn and keep the ore in a state of ignition by their own combustion. During this time it is necessary to turn and rake the ore diligently with the roast rake, "crutch," and shovel, in order to keep always presenting new surfaces of the glowing ore particles to the atmosphere, and thus to accelerate the desulphurization. Quantities of vapor of sulphurous and arsenious acids (so called Roast Gases), are developed. The greater part of the period of desulphurization takes place on the lower hearth. This period lasts 3½ to 4 hours, during which the fire must not be increased too much, lest a premature agglutination of particles of ore take place, which would interfere with a proper roasting.

During the period of desulphurization the ore loses the powder form and becomes more and more flocculent and bulky. The last two hours of the period of roasting, constitute the period of *complete roasting*. The charge ceases to emit gases, and must, therefore, be strongly ignited in order to decompose the sulphides of the metals and the sulphates of the metalic oxides. After the completion of the roasting (*i. e.* 8 to 10 hours), the charge is drawn out of some convenient working aperture, at a red glow into a car which has been pushed under the furnace sole, and a sample is taken for assaying; the remainder is dumped into the receptacle for the particular row of furnaces to which it belongs, cooled off with water and left till it is needed for smelting. The charge which is drawn out, must have been roasted down to 4–5 p. c. of sulphur, whereas its percentage was originally about 25 p. c.

For the determination of the percentage of sulphur, a weighed quantity of the charge is pulverized with three times its bulk of carbonate of soda and saltpetre This mixture is melted up, dissolved in hot water, and filtered into a beaker glass, to which is added a little chemically pure chlorohydric acid; and is then titurated for sulphuric acid. The daily number of workmen to a furnace is six, two going on every eight hours. One looks out for the muffle and the new charge, the other finishes the roasting of a charge, and attends to the firing.

As the muffleman has less to do, they change about every four hours.

The average consumption of fuel in 24 hours is about 7 bushels of hard slaty coal with a large percentage of ash. A bushel weighs two centners.

Middle Products of the Lead Process.

1) *Slag.* The aim is to make this a very fusible silicate of the protoxide of iron, the earthy oxides, and the oxides of zinc and manganese with a little lead (in reality about 5 p. c., containing 0.005 p. c. silver). Of this slag a part is used in compounding the new charge, and the rest in extracting silver and lead in the English furnace.

2) *Lead Matt* is a combination of several sulphides of the metals. principally of lead, but containing also sulphides of iron, copper, zinc and silver. The matt contains on the average 25 to 20 p. c. lead, 10 to 15 p. c. copper and 0.1 to 0.15 p. c. silver. In 24 hours about 10 to 12 centners of matt are formed.

The matt is stamped, and roasted in the hearth and muffle furnace, after which it is again mixed with slags and various materials rich in lime, and brought to the cupola furnace, in order to extract as much as possible of the silver and the lead from it, and to increase as much as possible its percentage of copper. It contains the larger quantity of the copper in the compounded charge. The second time the matt is treated, it is called the "modification" of the matt, and takes place after the conclusion of a run, in the same furnace in which the lead process itself is conducted.

(3 *Raw Lead.*—Which collects in the sump of the furnace, after the above two processes, is a lead in which various impurities, such as arsenic, antimony, and copper, exist in greater or less degree. The greater part of the silver of the charge is collected in this raw lead. It contains from 0,6 to 0.8 p.c. of silver and sometimes with very rich Dürr-ores reaches 1 p.c. of silver. About 16 to 18 centners are produced daily. In order to separate the lead and silver, this raw lead is either directly cupelled, or (which is the case except with the very pure ores) it is refined to get rid of the impurities, then submitted to Pattinson's process to concentrate the silver, and finally cupelled when it reaches about 1.5 to 1.6 p.c. silver.

Lead Speiss is produced, though more rarely. It is composed of iron, copper, cobalt, nickel and arsenic. If it forms in any quantity, its place is between the raw lead at the bottom and the lead matt immediately above it, so that the order in which these products lie is (counting from the bottom), 1st, raw lead; 2d, lead speiss; 3d, lead matt; and 4th lead slag. It usually adheres to the matt, however, and is submitted to further treatment with the latter, until a sufficient quantity is obtained to make a disc easily raised from the pot, into which the molten mass is drawn off.

The expenditure of fuel per day is thirty to thirty-two bushels of coke.

The force necessary to keep a furnace in constant operation consists of six men, three by day, and three by night, who have twelve hour shifts. They are divided into smelters, assistants, and slag-runners; of each of whom there is one in each shift. The smelter has the responsibility of taking charge of the furnace and conducting the process. The assistant has to help him as much as possible, and especially feed the charge into the furnace, under direction of the smelter. The slag-runner has to remove the slag to the dump heaps, and keep the part of the floor over which it runs, always in order, and free from obstructions.

Modification of the Lead Matt.

This is always taken up at the close of a run of the lead process. The matt is stamped and roasted as completely as possible, mixed in the slag from the same process, and with furnace ends from the lead process, and smelted in a cupola furnace. There is no definite relation of parts in the mixture. Generally, to about 40 cwt. of roasted matt 80 cwt. slag are added. It smelts very rapidly, because the mixture is very fusible, and is drawn off six to eight times in a day.

The products are:—1st, Slag; 2d, Matt (modification); and 3d, Raw Lead.

The manipulation in this process is the same as in the lead process.

Copper Matt.—The matt which falls in the treatment of the modified matt, is called copper matt. The object is to increase the percentage of copper, and the partial extraction, at least, of the silver and lead, of which this matt still contains no small amount. This, and the spur process, are undertaken at the end of a lead matt run, in the same kind of furnace as in the lead matt process. The matt is stamped or roasted, and smelted with litharge reduction slag, and a small percentage of fluor-spar, lime and slag of the same process. Care must be taken with the roasting, as this matt melts more easily than lead matt, on account of its higher percentage of copper. In twenty-four hours, about 60 centners of copper matt, or about 30 centners of spur matt, are produced; but besides these, raw lead and some speiss, which latter goes to the lead matt process.

Concentration Process.—By means of spuring, the matt has been brought up to 40 to 50 per cent. of copper; and in order to increase the percentage of it still more, it is now concentrated in the reverberatory furnace. Reagents are added to it, calculated to evolve a concentration of copper matt as free as possible from iron, and suitable for vitriolizing. It is stamped and roasted, and mixed with quartz and heavy spar (or barytic slags from previous runs). The use of the baryta is to assist in slagging off the iron; the principal object of the process being to reduce the percentage of this metal to a minimum.

The separation of the silver and lead is really of secondary importance, because these metals are entirely collected in a residue left during the course of the next operation, or that of vitriolization. Charges contain 18 to 20 centners of matt (of which by far the greater part has been washed), and 10 to 12 centners heavy spar and quartz—the latter about one-half to two-thirds of the mass. As before stated, this can be replaced by barytic slags.

Speiss Process.—The plumbiferous and pyritic material excerned in the course of the lead and spur matt processes, containing 0.4 to 0.5 per cent. of silver, and 1 to 2 per cent. of nickel and cobalt, is made of value by the speiss process. It is mixed with the hearth of cupellation and barytic slag from the concentration-copper process, besides some heavy spar. There result from this, speiss with 12 to 13 per cent. of nickel and cobalt, and copper matt.

This raw speiss is subjected to two or three meltings with various reagents, such as litharge, cupellation hearth, highly silicious slags and heavy spar, and finally becomes a speiss with about 0.03 per cent. of silver, 15 per cent. of copper, and 15 to 18 per cent. of nickel and cobalt. This operation is called the desilverizing of the speiss, or the separation of silver from it. The thus desilverized speiss is placed in a small reverberatory furnace with 50 to 60 per cent. heavy spar, and 20 to 25 per cent. quartz, and refined. The result is a copper matt, and a natural speiss, almost free from iron, with about 40 to 50 per cent. of nickel and cobalt, and 10 per cent. of copper. This product, which is an educt in so far as it is not further treated at the Freiberg Smelting Works, commands a good price at the cobalt blue manufactories.

Recently, the refining and desilvering of the speiss have been accomplished at one time. The speiss is refined with heavy spar and quartz, and after the slag is drawn off, about one or one and a half times the amount by weight of lead poor in silver, is added to the molten mass, and stirred well, the fire being increased. After this, the mass is drawn off into some convenient receptacle; and the products are, raw lead, copper matt, and a speiss much richer in cobalt and nickel, and containing 0.01 to 0.02 per cent. of silver.

Refining Raw Lead.—This consists in gradually raising the heat to the melting point, and scraping off the less fusible impurities which float, as scum, on the surface of the metal bath. The lead is kept at a low red heat, and air is freely admitted to its surface.

Lead Slag, or Raw Process.—These two names really designate the same process, and they exist because, at the Muldner Works, the lead slag, besides the ores, is subjected to it, while at the Halsbrückner Works only the Dürr ores and reagent ores having less than 0.1 per cent. of silver, are treated in this way, the lead slag from the Pils furnace being thrown away as worthless. Such ores, of course, are also treated at the Muldner Works.

The object here is to collect the small percentage of silver in an iron matt, which is afterwards roasted at the sulphuric acid works, and provides the latter, to a great extent, with sulphurous acid gas, while the argentiferous iron oxide which is the other product, forms the most valuable base for the composition of the slag in the lead process, and exchanges its associated percentage of silver for the sulphur of the Galena, in the evolution of the raw lead. In the following remarks, the lead slag process will be considered, but it is to be understood that it differs from the raw process only in admitting to the same treatment the product from which it derives its name.

The Pattinson Process, or the Concentration of Silver in the Raw Lead.

This process was invented in the year 1833 by Mr. Pattinson, of Northumberland, originally with the design of desilverizing leads so poor in silver that they could not be economically cupelled. More recently, this process has also been applied with advantage to leads rich in silver. The plan is to make a lead richer in silver, which diminishes, firstly, the volume of lead to be subjected to cupellation; and secondly, the loss of lead. The plain explanation of the principle underlying this process is as follows:—

A lead containing some silver is melted up in one of a row of large iron kettles, capable of containing from 200 to 250 centners (20,000 pounds, or 10 tons), and then allowed slowly to cool, the fire being withdrawn. While the molten lead is slowly cooling, it is carefully stirred by means of a large perforated iron ladle. In cooling, numbers of crystals are continually being formed and deposited in the bottom, the mother-liquor, or that part which remains molten, containing more silver than that which crystallizes out. The ladle is run down the sides, and scraped over the bottom of the kettle, and then drawn up slowly, and struck once or twice to permit the mother-liquor to run out through the perforations. The crystals are then transferred to the next kettle to the right hand. The consequence is, that at one end of the battery or row of kettles, almost pure lead is obtained, while at the other the required richness, 1.4 to 1.5 p. c. is reached.

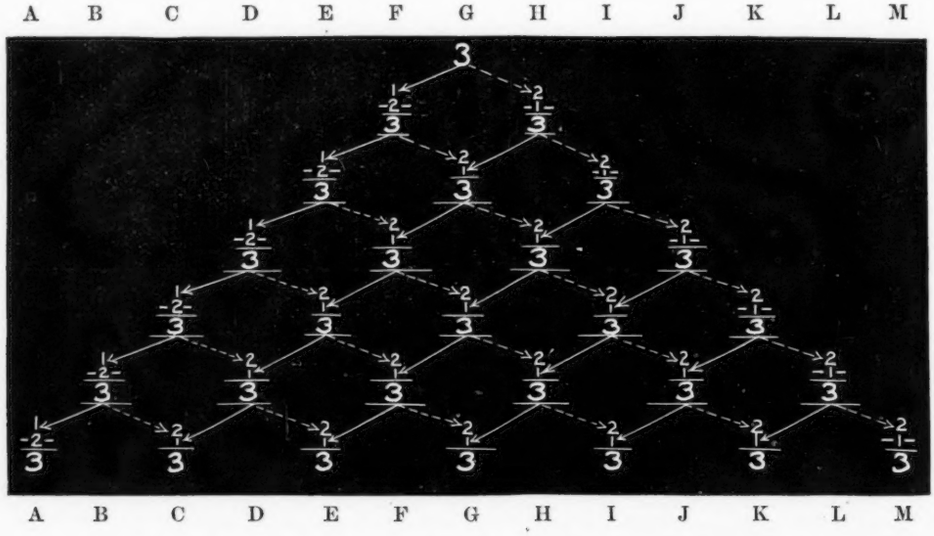
The purity of the lead has especial influence on the working of the process itself, so that the lead which is subjected to Pattinsoning must first be refined, in order to remove the arsenic, antimony and sulphur which it contains. The latter substance especially must be guarded against, as it not only interferes with the proper course of the work, but destroys the kettle itself, as a refining experiment with one of these kettles in Freiberg, and the fate of a whole battery of them, under the charge of an incompetent man in the West, abundantly prove.

The point to which it is possible to carry the separation by this method is about $2\frac{1}{4}$ per cent. of silver, according to experiments conducted at these works. Here the formation of crystals becomes slower and slower, and the still molten mass shows an unmistakable tendency to congeal and harden into a perfectly homogeneous mass. The explanation of this is, that up to this percentage the melting point of the alloy is lower, but above this it is higher than that of lead. Certain it is, that the melting point of an alloy of equal parts silver and lead (or even three parts of lead and one part of silver) is higher than that of pure lead.

The process can be undertaken either with or without intermediate crystals.

1. The Two-third System without Intermediate Crystals.—The following is the manipulation of the two-third system without intermediate crystals :—

After the lead in the kettle has been melted, and the scum forming on the top (copper, arsenic and lead) has been removed, the fire is almost entirely raked away, and the fire-door under the kettle opened. Water is then carefully sprinkled on the surface of the molten lead bath. This causes the lead near the edge of the kettle to solidify. These solid lumps are broken off and stirred into the rest of the lead, by which means the temperature of the whole mass is evenly lowered. When this lowering of temperature has reached a certain point, the mass becomes viscous from the beginning of the formation of crystals (which are small octahedra). Two workmen now grasp the ladle, and sink it into the kettle, along the sides and bottom, over which it is scraped to collect the crystals deposited there. It is then raised by making a fulcrum of the rim of the kettle. Here it gets two good shakes, to force out the liquid contents of the ladle through the holes. The ladle and its contents are then slid over to the next kettle to the



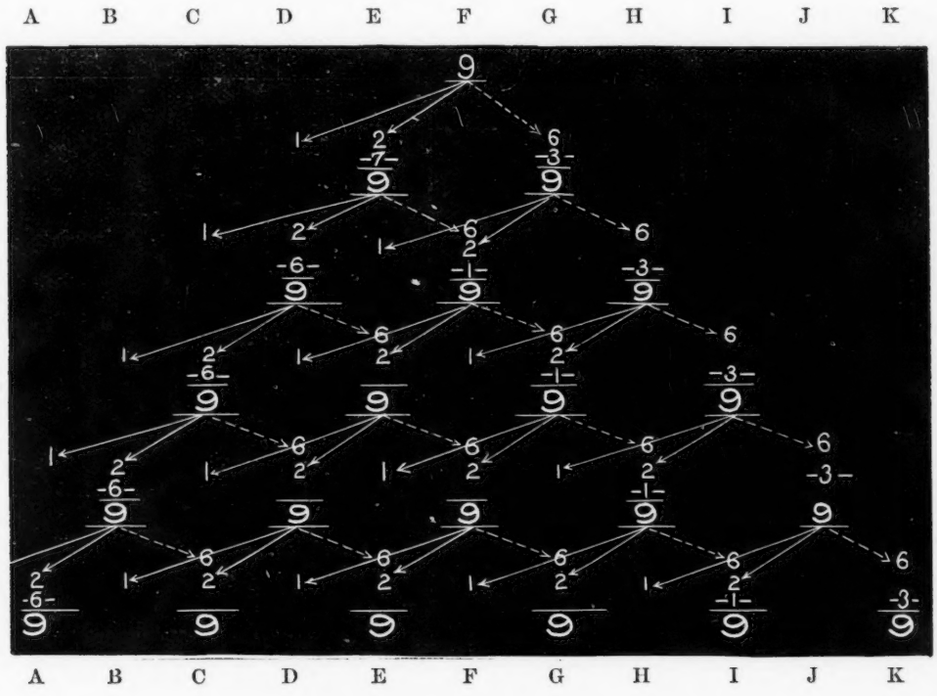
right, on a movable traveller, and the crystals are turned into it. This kettle has been already heated, so that they melt immediately on being placed in it. When two-thirds of the original contents of the kettle have been transferred to the kettle to the right, the remainder is ladled in a liquid state into the kettle to the left. This latter one-third is, compared to the original mass in the first kettle, rich in silver, and the two-thirds which have gone in solid crystals to the right comparatively poor. These two are now treated in the same way, the two-thirds crystals from the kettle on the left being ladled into the middle kettle in which the operation began, into which comes also the one-third mother-liquid from the kettle on the right, while one-third still richer mother-liquid goes into the next kettle to the left, and two-thirds still poorer lead crystals go to the kettle still further to the right. Soon the whole battery is in operation, the alternate kettles, at the close of any one operation, being empty, and the same kettles, at the close of the next step, full. In order to fill up the kettles into which respectively one-third and two-thirds of a charge have been put, refined lead, of various percentages of silver, is stamped, assayed and distributed to the different kettles

of the battery; so that lead of the required percentage is always on hand to fill up any kettle. In order to comprehend this more clearly, let us suppose the battery to consist of the kettles *A B C D E M*, and let 3 = capacity of each kettle.

Assume that lead of a known percentage of silver is introduced into the middle kettle of the battery (G). Then 2 of crystals go to H and 1 of mother liquor to F. Each of these is filled with lead of a richness corresponding to that of its contents, and the process is continued by allowing F and H to crystallize, whereby 2 from F are transferred to the now empty kettle G, and 1 to E. From H, 2 are carried to I and 1 to G, which is just filled from the two kettles next to it. This is continued, the number of kettles increasing until lead of the required silver-percentage in one end, and of the necessary purity at the other, is obtained. In the above diagram the numbers between two dashes represent thirds of lead which have to be added from lead at hand to fill a kettle, but are not transferred from any other kettle. The $\frac{2}{3}$ of a kettle which are carried as crystals to the right, are indicated by dotted lines ending in arrow heads; the full lines ending in arrow heads lead to the one-thirds, or the richer mother liquor.

2. Two-thirds System with Intemediate Crystals.

By this system $\frac{2}{3}$ of the contents of the first kettle are transferred to the neighboring kettle to the right, as before, in the form of crystals, but after this is done the remaining mother liquor is treated in the same way; the first two-thirds of the one original third ($\frac{2}{9}$) being transferred as crystals to the first kettle to the left, and the remainder $\frac{1}{9}$ being ladled, as the mother liquor, into the second kettle to the left, as thus:



It will be observed that each of these kettles represents a certain percentage of silver. The next to the last kettle on the "rich lead" side is crystallized, without intermediate crystals. During the process a button is obtained from each kettle, for analysis, in order to ascertain exactly how the concentration is proceeding. At every kettle there are employed two workmen who complete two crystallizations. One fireman attends to firing the furnaces of the battery under direction of the foreman.

"Poling," or the Production of Type Metal.

The Abstrich obtained by scraping off the scum which forms in the Lead Refining Process after the mere mechanical impurities of the first fifteen minutes of melting have been removed, is divided into two parts. (1) The Abstrich which is formed during the first half of the time. (2) Abstrich. (Abstrich consists, in general terms, of arseniates and antimoniates of oxide of lead.)

The desilverization of the 1st abstrich consists in melting it in a refining furnace, whereby the raw lead which has been mechanically mixed with the abstrich is liquated, while the abstrich itself, remaining unmelted, floats on the surface and can be scraped through the open door of the furnace into iron pans.

The lead which is thus separated is drawn off into a hemi-spherical kettle with a long nozzle, and is poured by means of this into a series of radiating lines of iron moulds. The desilverized abstrich is melted in cupola furnace with coke to a lead tolerably rich in antimony. In order to get rid of the copper still more completely and to obtain a product in the form desired for commerce, it is again melted gradually in a Pattinson kettle, and the lead is entirely freed from copper by successive formations of "Schlicker," aided by stirring with a pole of green wood. The heat decomposes the wood, and the gases and steam which rise through the molten metal occasion a still further agitation of the particles and bring every part to the surface. In place of poles an iron cage filled with faggots of green wood, and fastened to the end of a long screw fitting into a nut which is supported by two iron rods to uprights in the masonry around the kettle, is employed. Two arms like those of a letter press allow the cage to be raised and lowered, and at the same time turned round and round in the molten mass.

Cupellation.—This operation consists in a further manipulation of the Raw Lead from the Lead, and Lead Matt Processes after its refining and concentration. The plan is to separate the lead and silver by an oxidizing, melting in contact with flame, on a covered hearth and with the aid of an artificial draught. The air admitted through the tuyeres oxidizes the lead, and the melted oxide being specifically lighter than pure lead floats on top and is easily separated from it. In this way the silver, which is with difficulty oxidized, is obtained comparatively free from impurities, and containing from 90 to 95 p.c. of silver.

The construction of a cupellation furnace being generally understood needs no mention here.

After the melting of the lead the fire in the furnace is increased.

The fuel consists of split faggots. About 5 to 5½ cords are consumed in cupelling 350–380 cwt. of lead in 75 to 80 hours, counted from the time the lead was put in the furnace. At the same time the fire is increased, the blast is increased also. Supposing the lead not to have been entirely refined, an abstrich is first formed on the surface of the molten lead, and is drawn out with the scraper (a small round piece of wood, 6 inches in length and 1 to 2 inches in diameter, fastened crosswise to the end of a long iron bar).

After these impurities have been removed, the real litharge formation begins, and the molten oxide is run off by means of little cuts made in the dam of clay by the working door. An iron mould in the shape of a rectangular prism lacking 3 sides is placed with one open side against the wall of the furnace immediately under the working door, and in filling, this mould cools, and the litharge is transported in large blocks of from 16 to 17 centners to an adjoining room, which are broken in pieces in order to separate the red litharge from the yellow.

These are to be distinguished :—

1. *Yellow litharge*, with about 0.04 to 0.05 per cent. of silver, is smelted in the cupola furnace.

2. *Red litharge*, with very little silver, is found in the interior of the lumps of litharge obtained from the cupillation.

3. *Separation litharge*, which is produced just before the silver blicks ; *i. e.* the last portion of the lead separates from the silver, and the latter suddenly assumes a bright, clear surface.

As the surface of the molten lead becomes continually lower, it is necessary to cut the groove for the melted litharge deeper and deeper, and great skill and experience are required to prevent the rich lead escaping with the litharge. The absorption of the liquid lead into the sole of the hearth gives rise to the formation of bubbles of carbonic acid from the calcareous mass of which it is composed, and this gives the cupeller a means to guide him in running off the litharge. The groove is not cut till this border of bubbles is about two inches wide. After so much litharge

has run out of the first groove that the litharge mould has been filled three times, the groove is closed, and enough refined lead is added to bring the contents of the furnace once more to the old level. Another groove is then cut near the first one, and three moulds are filled through this; after which a third groove is cut still further to the left, etc. After this, when the requisite amount of lead has been added, the first groove is again opened, &c., till each groove has been used three times, at each time filling three moulds of 16 to 17 centners each, which makes $16 \times 17 = 432$ centners.

The amount of air conducted through both tuyeres per minute is equal to 180 cubic feet.

The charge of the cupellation furnace during the litharge period requires very great skill and experience from the cupellers. As the surface of the lead sinks more and more, the tuyeres must be more and more inclined to bring the current of air upon it. There seems to be no difference between the chemical constitution of red and yellow litharge. According to the most accurate results yet reached, the proportion of red lead which is obtained appear to depend upon the purity of the lead and the length of time it takes in cooling.

The nearer the process approaches to the "Blick," the slower is the formation of litharge, till at last it can only be continued by a very strong fire. With the exception of this part of the litharge period, the temperature during that period must be lower than during the formation of "Abstrich," with which cupellation begins.

Silver Blick.—When the molten litharge becomes so small in quantity that it can no longer cover the surface of the silver beneath it, the mass becomes suddenly very bright, and shows the sea-green color of melted silver.

Figures like flowers and waves appear on the surface of the molten silver, and are occasioned by the covering of fused litharge forming no longer a continuous sheet on the bath, but becoming more and more net-like, while the bright silver below shines more and more through the openings, till finally the last particles of litharge are driven to the edge of the hearth. This is the juncture to which the name "Silver Blick" has been applied. As soon as this appearance ensues, the fire is quenched quickly by throwing pails of water upon it, the blast is stopped and hot water is poured upon the "Blick Silver" by means of an iron trough in order to cool it as rapidly as possible.

When the "Blick Silver" to be obtained, is too heavy to be easily handled, a "silver knife" or thin iron beam with several branching arms on each side, is lowered down into the metal before it hardens, so that it can be easily broken in pieces. Without this arrangement it would be very difficult to break the silver, and considerable loss would be likely to ensue in the effort to do so. The cover of the cupellation furnace is lifted off and swung to one side, and the silver is removed to some place of security until ready for refining. This "Blick Silver" contains still 4 to 5 p.c. of impurities, chiefly copper, lead, and bismuth, the latter having even a greater affinity for silver than lead. The weight of one of these "Silver Blicks" is from 2 to 6 centners. Only a small part of the silver goes into the hearth or elsewhere into the plumbiferous products of cupellation.

The sole of the hearth which is soaked with oxide of lead to a depth of 2 to 3 inches, breaks off in separate scales from that portion of the mass into which the litharge has not penetrated. It is known simply as "Hearth," and is either treated in the Lead Matt Process as a reagent, or is smelted in cupalo furnaces by itself with coke to a pure Raw Lead, the earthy constitutents of the hearth mass forming a slag very difficult to fuse. The part of the hearth which has not been in contact with the molten litharge is broken up and used together with new material in the formation of the next hearth in the cupellation furnace. By the treatment of foreign (American) ores, a "Blick Silver" is obtained containing 0.11 to 0.15 p.c. of gold. This is treated by itself. From the cupellation of 350-380 centners of pattinsoned Raw Lead there result 330 centners yellow and red litharge, of which the $\frac{1}{3}$ to $\frac{1}{5}$ part is red, and contains about 1.5 p.c. Silver. Red litharge is packed in kegs and sold, while the yellow is reduced to pure lead. The weight of the cupellation hearth is from 38 to 40 centners.

The "Blick Silver" before reaching the fineness required for the mint must be still further refined.

Refining of Blick Silver.—This work consists of a continuation of the cupelling process, whereby the Silver is so far purified from the other metals that it can be immediately used by the mint without further refining.

The silver refining furnace in which this operation is conducted very nearly resembles the English reverberatory furnace, but is smaller. It has, besides, a blast through two tuyeres situated near the fire bridge and one on each side

of it, and instead of the immovable brick vault over the hearth a movable iron cover, which, by means of an attachment to a windlass, can be hoisted and moved to one side, as is the case with the cupellation furnace.

It is necessary to prepare the material for its hearth sole at least two days before. It must be sifted as fine as possible and moistened with water. This mass is spread upon the hard burnt fire brick, and after being pounded hard is scraped into a basin form, the lowest point being in the middle, and the sole being here 1½ to 2 inches in thickness. In the centre of this basin a hemispherical pot is made in order to allow the silver to collect, and to render the ladling out more easy.

After all these preliminaries have been attended to, a small fire of coke is built upon the hearth in order to dry it, whereupon the cover is put on and luted with clay. Before the Blick Silver can be placed in the furnace, the latter must be not only entirely dry, but shortly before this must have been brought to the highest possible melting heat, as otherwise numerous cracks would appear in the hearth, and the silver would be more difficult to melt.

The hearth must, therefore, be brought to a bright red heat just before the Blick Silver is put in.

For this purpose, 8 or 9 hours before the introduction into the furnace of the Blick Silver, a light fire of stone coal is kindled in the blast furnace, and this is gradually increased until just before the Blick Silver is put in, the furnace has reached the highest possible temperature. In placing the blocks of Blick Silver into the furnace, care is taken to bring them near the fire bridge, where they get the greatest amount of heat. If all has not been put in at once, the remainder is added after the silver already in the furnace has been melted. The working door is then closed by an iron slab, and it, as well as all other apertures luted with clay, and the fire increased.

If after two or three hours the silver is melted, the heat must still be continued, and a weak stream of air must be admitted to the silver bath from the tuyeres on both sides of the fire bridge. From time to time the molten metal is stirred up with the stirring iron, in order to bring all impurities which may be contained in the silver to the surface. Finely pulverized hearth-mass is strewn over the surface, and aids in absorbing the liquefied oxides of bismuth and lead. It is scraped from time to time out of the working door. After several hours, during which the temperature has been maintained uniformly, and the molten metal well stirred, a small quantity is taken out in the assay spoon to ascertain how far the silver is refined. Only when the fracture shows satin lustre and perfectly white color is the silver of the requisite fineness. Next to these appearances is that of the reflecting power of the molten bath to be observed. When any of the implements are held over the surface of the silver, a perfect image must be observed in the latter. Very often it is found that, though the reflection is perfect, the fracture is gray and granular, a proof that the silver has absorbed too much oxygen from the blast. As the silver in this condition is brittle, and not suitable for the purpose of coining, the absorbed oxygen must be got rid of by strewing small lumps of coke of the size of a walnut upon the surface, whereby the oxygen is driven off in carbonic acid. As soon as it is evident that the silver is fine, and can be drawn out without exhibiting cracks at the edges, it is subjected to another high melting heat, in order to bring it into the proper condition to ladle out. Before ladling out, the blast is stopped, and a granular test is taken—*i. e.*, a little of the molten silver is taken out in the assay spoon and poured over the moistened ends of a brich broom into water, when it granulates. This is assayed to ascertain the degree of fineness. This silver is given to the Director of the Works for assaying. After this the silver is poured into iron pans holding 25 to 30 lbs., which must previously be coated with a layer of clay, as must also the ladle itself. The latter is heated red hot before being dipped into the silver, to prevent particles of the precious metal from adhering to it.

In this manner 20–25 centners of blick-silver can be refined in ten to twelve hours, with an expenditure of eight to nine bushels of slaty coal.

If it is desirable to refine more silver, it can be introduced into the same furnaces without changing the hearth. After ladling out, the oxygenated condition of the silver shows itself in the phenomenon of spurting. Silver possesses the curious power of absorbing oxygen in its molten state, and then suddenly giving it up just a moment before it congeals. This gives rise to a spurting of the silver, and to prove that during this phenomenon oxygen is really set free from the silver, it is only necessary to strew coal-dust on the surface of the metal. At the moment of the spurt this coal takes fire, and burns up with great rapidity. The blocks of silver are then turned out of the moulds, and

the little irregularities of surface are smoothed down with a file and brush. Its fineness must be now at least 99 per cent. of silver. It is usually about 99.4, and contains only traces of copper, bismuth, and lead. The degree of fineness is determined by a volumetric analysis.

After the silver has been refined, the little buttons of silver are collected from the hearth, and put aside to be added at the next refining. The part of the hearth into which the oxides of lead and bismuth have soaked (and which contains from 15 to 20 per cent. of bismuth, and 0.15 to 0.2 per cent. of silver) is removed, and submitted to the bismuth separation process.

If the blick-silver is to be treated for gold, it is freed from lead and bismuth in the manner indicated, but, instead of being poured out into pans, it is granulated. The metal is ladled out into a cylindrical copper vessel filled with water. The ladle being filled is moved around and round, and the metal poured out in thin streams into the water, whereby the silver is very finely granulated.

It makes small porous masses of silver, and in this form is most easily attacked by acid. The copper vessel has two pipes, one above and one below. The cold water pours in through the lower, and escapes from this upper pipe. Unless the water is sufficiently cold, granulation will not take place. The separation of the gold from the silver is undertaken exclusively at the Halsbrückner Smelting Works, and consists in the treatment of the granulated and refined blick-silver with concentrated sulphuric acid and the addition of heat, whereby the whole of the silver is dissolved as "silver vitriol," while the gold which was combined with it remains behind in the form of a powder. The operation is performed in a dissolving or separation kettle of cast iron, which is walled in above a blast furnace. The kettle is covered by a copper cap during the application of heat and the period of dissolving, and a pipe is connected with this cover, through which the sulphuric acid vapors are conducted to a small condensation chamber of sheet lead, intended to catch all the little particles of sulphate of silver which may be carried off mechanically. From here the gases are conducted into a chimney. In the copper cover is an aperture through which the contents of the kettle can be constantly stirred. Six centners of auriferous silver are dissolved at one time in such a kettle; and to do this requires 12 centners of oil of vitriol, of which 5 centners are poured in at first, and the other 7 centners added from time to time. In order that the silver may not stick fast to the bottom of the kettle, the mass must be stirred continuously with an iron rod. At first there is a violent disengagement of sulphurous acid, and great care is necessary in firing to prevent the acid from boiling over. In eleven hours the dissolving is finished, and the solution is allowed to stand for ten hours more, in order that it may cool and the gold residue may settle. At the expiration of this time the concentrated solution of sulphate of silver is ladled into copper pans by means of a copper ladle, and transported to a large wooden vessel lined with sheet lead (silver precipitation vessel). It is here stirred with wooden poles; a piece of old copper sheeting is put into the tank, and it is heated by the introduction of steam to a temperature of about 70° C (158° Fahrenheit). The silver precipitates in the form of a grayish-white crystalline mud. In proportion as the metallic silver precipitates, copper vitriol is formed.

Towards the last, the liquor is tested for siver by chloride of sodium. When the dissolving is complete, the liquor is allowed to stand for ten hours, in order to permit the fine particles of silver to settle perfectly, and is then drawn by means of leaden syphons, into a basin where the settling is completed. After this, the fully desilverized liquor is conducted into the evaporation pans, where it is treated for copper vitriol. The "cement silver" which remains in the silver precipitation vessel is sifted in a copper sieve, to get out any particles of copper that may be mixed with it, and is then placed in a tank provided with a false bottom, in which a sufficient number of holes have been made for the escape of the liquid, and is well washed with hot water, until the latter ceases to give with chloride of barium the reaction for sulphuric acid. The waste water is collected, and as it contains sulphate of copper in solution, it is used to dilute future charges of sulphate of silver in the precipitation tank. The thoroughly washed cement silver is then pressed into bricks to expel the water as much as possible, and is brought, in the form of small cylinders, into an iron retort, and heated to redness, to drive off the last trace of water. It is then melted in Graphite crucibles in a blast furnace, with stone-coal in masses of 410—420 pounds, and poured into small cast-iron moulds, which have been smeared with tallow, a test of it having been previously taken to ascertain the degree of fineness. This silver is delivered to the mint with a fineness of 99.9 per cent.

Gold Separation Process.

If the silver is very poor in gold, two or three dissolvings of six centners refined blick-silver each, are conducted in the same kettle, so that the gold of eighteen centners or so is concentrated in it. The gold residue so left is very full of impurities—silver vitriol, metallic silver and anhydrous salts of copper and iron—and for its further purification, is boiled for three hours with concentrated acid, and allowed to cool and settle, the clear liquor being transferred to the silver precipitation vessel. It still contains anhydrous sulphate of copper and iron and metallic silver. It is boiled with hot water in a wooden tank lined with sheet-lead, in order to dissolve the salts. This boiling is repeated three or four times. The wash water of the boiling is precipitated with copper by itself, because a great deal of sulphate of silver is dissolved in it. It is colored green from the iron vitriol. The thus desilverized liquid is used to sprinkle roasted ore. The rest of the wash water of this gold is used like the wash water from the precipitated silver, to dilute the concentrated solution of sulphate of silver. The gold residue is now twice again well digested with 200 pounds of concentrated sulphuric acid in an iron kettle, the first time for eight hours, and the second time for one hour. This is done for the perfect separation of the undissolved silver. From forty centners of this material, enough auriferous residue is obtained to fill two small kettles. This is then put into a porcelain crucible, and boiled with hot water, in order to get rid of the sulphate of silver. The wash water is continually tested for silver.

The gold residue now, for the first time, assumes the brownish-yellow color of finely divided gold. It is well dried on plates of graphite, and then twice heated to redness, after being mixed with sulphate of soda, and boiled with fresh acid After each boiling, it is boiled with water. It is now melted in a Hessian crucible with saltpetre, to get out any lead that may still remain in it. After cooling, the crucible is broken, and the gold is melted over again in a graphite crucible, in order to free it from the saltpetre slag. It is then poured out, 99.4 per cent. fine, into small cast-iron moulds, in which form it is sold. A pound of gold is worth 466 reichsthaler.

Bismuth Separation Process.

It has been stated that bismuth exhibits a stronger affinity for silver than does the lead, and it is to this cause that we are to ascribe the marked predominance of bismuth over other metals in the hearth of the refining furnace, This hearth saturated with the last impurities which leave the silver as fused oxides, contains 20 p.c. of silver. It is treated for bismuth as follows : The hearth is stamped fine and digested in the cold, in earthen ware vessels, with equal parts of hydrochloric acid and water, in which the bismuth dissolves, while lead and silver remain in the residue The bismuth solution is drawn off by means of leaden syphons, and the residue is washed several times thoroughly, the wash-water being poured with the first solution into a large reservoir in which there is sufficient water. The whole. of the bismuth is precipitated, as basic terchloride of bismuth, in the form of a white mud. This is then filtered off and dried, after which it is melted in an iron crucible with the addition of calcined soda, coke-dust, and glass-powder, and reduced to metalic bismuth.

Vitriolization. This process consists in boiling the completely oxidized concentration matt with dilute sulphuric acid, by which treatment the copper is dissolved, and the silver and sulphates of the other metals remain as residue. This solution is allowed to stand and clarify itself, and then crystals are obtained by its concentration. These crystals (so called raw crystals) are dissolved and the solution concentrated again, giving crystals of sulphate of copper so pure as to be fit to bring into commerce.

The concentration matt is first stamped and sifted in order to get the grains as nearly as possible of one size. It is then roasted in the Hearth and Muffle Furnaces, but the muffles are not used in roasting it. The matt is put into the furnace by means of iron boxes. The weight of a charge is 10–12 centners and the length of time of roasting 16 hours. The roasting is begun with a light fire until the matt, by reason of its percentage of sulphur, ignites. During the last 4 to 8 hours it requires a strong fire for the purpose of decomposing the metalic oxides. The charge is turned every two hours (from the chimney to the fire bridge). Besides this it must be well worked over with the shovel and the lumps which are formed, broken up. In front of every working door is a workman who has an eight hour shift. In 24 hours the consumption of fuel is 7 bushels of coal. The concentration matt melts so easily that in spite of the

greatest care portions of it will adhere to the hearth sole, and these portions must be removed by an iron instrument adapted to the purpose. Those agglutinated parts are stamped and again roasted for the oxidation of the enclosed pieces of matt. The roasting is continued for 16 hours in charges of from 10–11 centners. The completely roasted matt is drawn out of the furnace in iron boxes, and transported to a mill where it is first sifted, the fine dust fed through two sets of mill stones by which it is very finely pulverized, is again sifted and then placed in the dissolving tanks. That portion of it which is too coarse to pass the sieves is stamped and roasted again in charges of 10 centners. The solution is conducted in cylindrical vessels lined with sheet lead, and whose bottoms are made of antimonial lead.

There are at present at the Halsbrücke smelting works two dissolving tanks, one great and one small one, the former capable of holding 4 centners of finely pulverized roasted concentrated matt. About 9 centners of acid of the lead chamber (48° to 50° Beaumé) are introduced into the larger of these vessels, and this is then diluted with twice the bulk of mother liquor from previous operations.

The mixture of acid and mother liquor is heated to the boiling point by the introduction of steam, and the roasted and pulverized matt is then stirred in with wooden stirring-instruments in small quantities, while steam is steadily admitted. In three-quarters of an hour the material is completely dissolved. The steam is now shut off, and the liquid allowed to stand a quarter of an hour, in order that the finely divided argentiferous residue may settle, and the saturated solution of 40°–42° Beaumé clarify itself. In twenty-four hours, eight solutions are made in the larger tank. After the liquid has cleared in the larger vessels, it is drawn off, by means of leaden syphons, into the crystallization tank. Such a tank has a capacity of 100 cubic feet, and holds the liquor of four solutions. All these tanks and vessels are lined with sheet lead.

The argentiferous residue left in the dissolving tanks is well washed, in order to separate the copper vitriol, then washed down through the cock, in the lower part of the tank, and just above the bottom, into a receptacle beneath, where it is again well washed, and then filtered through linen cloth, and finally dried in a furnace, and conveyed to the Lead Process, to extract the silver.

This residue consists in the main of sulphate of lead and metallic silver, particles of sulphur, and anhydrous salts of copper and iron. It averages 30 per cent. of lead, 2 to 2.5 per cent. of silver, and 7 to 8 per cent. of copper. In the crystallization tanks there are suspended numerous bands of lead, to which the crystals of sulphate of copper attach themselves. Crystallization requires from eight to ten days.

These first crystals (raw vitriol), which, on account of the concentration of the solution, are somewhat unsightly in their appearance, are re-dissolved either in water or in mother-liquor, in other lead-lined tanks, heated, as before, by steam.

This liquor is crystallized in the same way, and produces the crystals of copper-vitriol which are required by commerce.

A portion of the mother-liquor which has only a strength of 25° Beaumé more or less, is used to dilute the strong sulphuric acid at the commencement of vitriolization, while another portion is concentrated, by evaporation in leaden pans, to the previous strength of 40–42° B., and given over to crystallization. The vitriol crystals from this part of the liquor are dissolved and crystallized again. The mother-liquor of this crystallization contains much iron, besides all the constituents of the matt, of secondary importance, manganese, zinc, arsenic, and a considerable amount of nickel; and it is used to quench the red-hot ore from the roast furnaces. The mother-liquor of the copper vitriol is used again and again to dilute the strong acid, as has been said before, until it becomes so rich in iron that it can no longer be used without rendering the copper crystals impure from that metal.

The pure crystals of copper vitriol are washed in water, to free them from adhering acid, then dried on long shelves, in a room into which warm air is admitted, and finally packed in barrels and sold.

The Manufacture of Sulphuric Acid.

I. *Form and Composition of the Ores and Products rich in Sulphur which are adapted to this Process*:—
There are applied to the production of sulphuric acid,

1) The raw matt from the lead slag process : and

2) The blendic and pyritic Dürr and flux ores which come to the lead slag process. These either in natural lumps (or in agglutinated masses resembling lump ore), or stamped, or pulverized.

The sulphur of the raw matt amounts to 22–25 per cent. ; that of the lump ore, 32–35 per cent. ; and that of the powdered ores, 28–30 per cent. Ore lumps are prepared artificially as follows :—

Rich and infusible ore dust is well mixed in a large wooden tank, and moistened with dilute sulphuric acid. The mass is then worked over with a wooden rake, pressed into iron moulds, cut into small cubes, and dried on the iron slabs over the condensation canal of the roasting furnace. In this manner these acquire such firmness that they can be roasted in kilns just like natural lump ore. The cause of this solidity is to be found in the formation of sulphates of zinc and alumina, compounds which are not easily decomposed by heat.

All these lumps (natural and artificial) are roasted in kilns, but the ore dust is desulphurized in Gerstenhöfer's dust roasting furnace.

The kilns are a kind of cupola furnace in their main features. The inside is a space either like a parallelopipedon, or like the frustrum of a pyramid in form. They are of many different sizes. The high kilns are principally used in the roasting of the raw matt, and the low kilns in roasting the *lump ores* and *ore lumps*.

On the workman's side of these kilns are openings at different heights from the ground, through which the workman can reach all parts of the mass within, by means of suitable iron instruments, and loosen it. The kiln is put in operation by the workman filling it two-thirds full of already ignited raw matt, then kindling a fire underneath, and after the walls of the furnace are red hot, letting in the charge of raw matt through the roof.

The raw matt burns of itself by virtue of its percentage of sulphur. After the lapse of a few hours, a portion of the charge is drawn out of the opening nearest to the sole of the kiln, and this causes the whole superincumbent mass to sink, leaving place at the top for a new charge of raw matt. The new charge is distributed evenly over the surface of the already ignited portion.

About 18–20 centners of raw matt is introduced at once or a charge, and this is repeated about every twelve hours. The introduction of the charge always follows the drawing out of a part from below. The interior of a Gerstenhöfer furnace is a space in the form of a rectangular prism, across which from side wall to side wall a great number of triangular prisms of burnt clay are inserted, with one of their faces upwards.

There are two narrow slits in the roof of the furnace, through which the ore dust is fed through rollers.

Under these slits are two larger triangular prisms, having their edges up, so that the pulverized ore, falling upon these first, is diverted to the right and left, and falls through the entire height of the furnace, resting a short time on each bar. These roast bars must be previously heated to redness by a fire kindled in the furnace itself, but gradually withdrawn as the ore itself ignites.

The powdered ore which collects on the flat sides of the roast bars is ignited by them, and once fairly ignited, evolves such a heat that all other fire is unnecessary. The atmospheric air requisite for combustion is partially introduced through numerous air holes in the workman's side of the furnace, and (in case more air is needed than these can supply) by means of a ventilator. With this exception the furnace is closed, and the products of combustion, of which sulphurous acid forms the greater part, are collected.

The feed is continuous, and 40 cnt. pulverized ore can be roasted in such a furnace in one day.

The gases are first conducted through a condensation chamber, in which the greater part of the arsenious acid condenses, and from here through a subterranean canal (which also serves to condense the still remaining arsenious acid and small particles of ore carried forward by the draught) to the lead chamber, where, by the necessary nitric acid and steam, sulphuric acid is formed. The atmospheric air required to convert the sulphur into sulphurous acid flows into the furnace, and from there it goes with the roast gases into the lead chamber. The amount of sulphurous acid in the products of combustion does not exceed 6–7 per cent. by volume, and indeed in the roasting of the raw matt it is not above 4 per cent. The lead chambers are large rooms lined with sheet lead, in which the formation of sulphuric acid takes place. The lining sheets of lead hang from a strong scaffolding and are soldered together with lead. A "system" of chambers consists generally of one entrance chamber, two main chambers, and two roof chambers which are connected with each other by strong leaden pipes. The entrance chamber receives the nitric acid

necessary for the oxidation of the sulphurous acid. The main part of the process takes place in the two middle intermediate chambers, and the roof chambers are designed to condense the particles which have been mechanically carried by the gases through the other chambers. The roast gases escape here through a chimney into the open air, the greater part of the sulphurous acid having been converted into sulphuric acid. The gases that thus escape are principally brown vapors of hyponitric and nitrous acids, nitrogen and a small quantity of sulphurous acid, and some steam. The steam necessary for the process is generated in a steam boiler outside of the lead chamber building, and is conducted through a cast-iron pipe either through the side or better through the roof of the lead chamber, and it must have a certain tension on leaving the pipe in order that it may disseminate itself over the whole interior space.

The nitric acid which is required in the production of sulphuric acid is made from Chili saltpetre and sulphuric acid of 60° B. The decomposition of the saltpetre (nitre) takes place in close cast-iron retorts, underneath which is a fire place and both ends of which are closed by movable iron doors. 230 lbs. of sulphuric acid and 250 lbs. of saltpetre are put at one time into a retort of this kind and this is repeated every two days. The nitric acid gas mixed with peroxide of nitrogen is condensed in earthen jars (Woulfe's jars) containing water.

From 1 centner of saltpetre 150 lbs. of nitric acid are obtained, or 60 p. c. nitric acid of 36° B. This nitric acid which condenses in the first jar has a strength of 40°–45° B., in the last jar about 15° B. The jars are connected by earthen necks in the usual manner.

As secondary product of this part of the sulphuric acid manufacture are 230–240 lbs. of sulphate of soda (Glauber Salt). At the Muldner works there are three such systems of lead chambers, the first containing 94,000, the second 134,000, and the third 160,000 cubic feet. The lead chambers of the Halsbrückner Works enclose 159,000 cubic feet. In the lead chambers the sulphuric acid is obtained as hydrated acid of 48° to 50° B., and containing a large percentage of arsenious acid. The acid collects in the bottom of the chamber, and must be drawn off from time to time into a basin provided for its reception. For greater facility in observing the strength of the acid, dropping apparatuses are introduced at different places on the sides of the lead chamber where the newly formed acid, trickling down the inside of the walls, is caught and allowed to drop into a little lead cup, from which it is again conducted into the chamber by a leaden pipe. In this way it is easy to test the strength of the acid and thus to regulate the amount of steam, nitric oxide, &c., which are to be admitted. The height of the acid in the chamber is ascertained by means of glass tubes fastened into the sides like the float water-guage of a steam boiler. If the acid in the little cups shows a tendency to exceed 50° B. in strength, either less nitric oxide gas must be admitted, or the amount of steam increased. A system of lead chambers enclosing 94,000 cubic feet can produce daily 50–60 centners of sulphuric acid of 66° B., and the consumption of nitric acid amounts to 5–6 centners in 24 hours. A system of 160,000 cubic feet can produce 100 cwt. of sulphuric acid of 66° B., with a consumption of nitric acid of 8–10 cwt.

A normal run in this process is indicated partly by the warmth of the leaden walls (occasioned by the chemical processes going on inside), partly from the regular and rapid dropping from the dropping apparatus into the leaden cup before described, and lastly from the brown color of the gases which escape from the roof chambers. In order to be able to observe the color of these gases more perfectly, two small glass windows are inserted into the opposite sides of the chamber.

If the escaping gases are colorless or bright yellow it is an evidence that there is a lack of nitric oxide.

The purification of the acid of the lead chamber from arsenious acid is accomplished by means of sulphydric acid which precipitates it as tersulphide of arsenic. The sulphydric acid is produced from a raw matt free from zinc, which is obtained by smelting lump-ore free from blende without roasting and with slag in a cupola furnace.

This raw matt is broken into small pieces and treated with dilute sulphuric acid in a gas-flask with the assistance of heat from steam which is conducted around the flask. To aid the warming, these flasks are surrounded by iron jackets. The gas is led through a leaden pipe into a waste vessel partly filled with water, whose use is firstly to wash the sulphydric acid, and secondly to furnish a means of observing the course of the operation.

The residue which remains in the gas-flask and which is very rich in silver is carried to the smelting furnace. The solution of iron vitriol resulting from this production of sulphydric acid is evaporated to saturation, and then transferred to crystallization tanks, and crystallized in the same manner as copper vitriol. The centner of Green

vitriol brings one Thaler 10 neugroschen (one dollar). The sulphydric acid gas pours out into the precipitation tower, a large cylindric structure lined with sheet lead, which it entirely fills. Over this precipitation tower is a reservoir containing the still impure acid of the lead chamber which is allowed to trickle into the tower through openings in the bottom of the reservoir. As the acid enters it becomes saturated with the sulphurated hydrogen and the arsenic is precipitated in the form of a yellow mud. The sulphuric acid along with this arsenic mud runs into vats at the bottom of the tower and is allowed to stand till the latter has almost entirely settled, when the former is pumped up again into the reservoir, and again allowed to trickle down the sides of the tower, till a portion in a beaker glass shows little or no arsenic after being saturated with sulphydric acid and allowed to stand for some time. A pumping apparatus is used to carry the purified sulphuric acid from the vats at the bottom to the reservoir on the top of the tower. It consists of a small steam engine with horizontal cylinder, which moves the piston in an air cylinder, compressing the air through tubing in an air tight vat into which the acid has been previously run.

The tersulphide of arsenic is permitted to settle as perfectly as possible in lead-lined wooden tanks, the acid being decanted off as completely and clearly as possible by leaden syphons and run into the evaporation pans.

The yellow arsenic mud is washed thoroughly with water to get rid of the sulphuric acid. This is done in filtering vats lined with lead and provided with numerous apertures in the bottom by which the waste water can escape. The purified arsenical precipitate is taken out to the drying hearth, where it is freed of its water and transferred to the arsenic works for further treatment.

Evaporation of the purified sulphuric acid. This is undertaken in leaden pans, of which there are four on the same level or in terrace form one above the other. The pans must be very shallow to facilitate the evaporation, and the acid must not be more than 12 to 15 inches deep in any part of the vessel.

The degree of concentration to which the sulphuric acid is brought in this operation is exactly 60° B. A stronger acid would attach the lead at that temperature.

The foremost pan in which is the acid of 60° B. rests directly on the iron plates over the fire place. The acid to be concentrated is transferred from one pan to the other towards the fire, so that the last pan into which it comes is directly over the fire place, while the first one filled is furthest from the fire.

The steam from the evaporation, strongly impregnated with acid, escapes into the open air through a long hood connecting with a chimney which is so arranged as to hang directly over the pans.

Stone coal is used as a fuel for the evaporation. This process is continuous, *i. e.*, as much acid is let into the hindmost pan to be concentrated as of the 60° B. acid is taken out of the pan over the fire place. The further concentration of the 60° B. is undertaken in a platina retort of several cubic feet contents. The 60° B. acid is boiled in this platina retort, and the strong acid vapor conducted through an aperture in the platina cover through a helix which rests in a vessel filled with cold water, and into a receptacle under the end of the helix for the collection of the condensed vapor. This is removed to the evaporation pans, and again concentrated with the rest. The sulphuric acid of 66° B. strength being specifically heavier than the weaker acid, sinks to the bottom of the retort, whence it is removed by means of a platina syphon. This acid is run into glazed earthen ware pitchers and filled from these into carboys.

It is 66° B. perfectly colorless and transparent and oily, has specific gravity 1.84, and is tolerably pure hydrate of sulphuric acid From decomposition of the little organic materials of which the air is always more or less full, it gets very often a brown color. The carboys are covered with willow withes, and are each packed in a box with straw, the neck just protruding a little above the lid. After being filled they are closed by earthen ware stoppers, and sealed with melted sulphur and sand.

The centner of sulphuric acid of 66° B. is worth 2 thalers ($1.50), exclusive of the packing and carboy which costs 27 neu grochen (67 cts.). Some 60° B. acid is sold also at 1 thaler 12 n. gr. ($1.05). The cnt. of unpurified sulphuric acid of 60° B. is sold for 1 thaler 2½ n. gr. (81 cts). This is now extensively used to decompose the phosphates in the superphosphate manufactories.

The Manufacture of Various Arsenical Articles of Commerce.

The arsenic works are employed in the production of arsenious acid, metallic arsenic, and various sulphides of arsenic. The arsenical dust from the condensation chambers of the Roasting Furnaces furnishes the most of the

material from which these products are derived, but besides these certain Dûrr and lead ores, very rich in sulphide of arsenic, are treated directly for this metal. The process is carried on in furnaces closely resembling the English Reverberating furnace with coke as the fuel. The furnace is connected with a very long condensation canal of brick in which the deposition of arsenious acid takes place.

The arsenical dust is brought upon the hearth through two holes in the roof of the furnace in charges of 10 centners, and is then spread out and submitted to a red heat. One workman has charge of such a furnace for 8 hours.

The arsenious acid contained in the dust is sublimed by the high heat and passes from the furnace into the canal. During the sublimation the workmen must continuously stir up and loosen the charge. In 24 hours 40–50 centners of such dust are treated and the expenditure of fuel is 10 bushels of coke.

The fine particles of ore contained in the dust remain upon the sole of the furnace either as powder or in a melted condition, and as they are very rich in lead and contain some silver, they are taken back to the cupel furnaces and mixed with the other argentiferous leads, form the charge for the lead process, but only when they have accumulated to such an extent as to leave no room on the hearth for a fresh charge,

The roasting of the arsenical ores is conducted in a similar manner to the roasting of the pyritic ores in the Reverberatory furnace.

The dearsenized ore is again roasted. The dust which settles in the condensation canal is a fine white crystalline powder. When several hundred centners of this powder have collected in the canal, the latter is cleaned out, the arsenious acid being packed in barrels made of strong staves and lined with paper. The centners is sold for $2\frac{1}{4}$ thalers ($1.69). It is applied to the manufacture of pigments, and in the manufacture of glass, in dyeing, and lately in enormous quantities in the preparation of aniline colors. That part of the arsenious acid which settles in the part of the canal nearest to the furnace is usually mixed to a certain extent with fine particles of ore dust, which have been mechanically carried along with it, and this is especially used in the fabrication of "White Glass" so called. This "White Glass" is nothing more or less than melted arsenious acid. It is a homogenous mass translucent and slighty yellow to milk white, with conchoidal fracture and strong vitreous lustre. The manufacture of "White Glass" is accomplished in small iron kettles which are placed over the fire place, their rims just reaching the level of the brick roof of the latter. Movable iron covers shaped like stove pipes and narrowing towards the top are placed over these kettles, and connect at their upper ends with the chimney. These covers are 3 to 4 feet in height and about $1\frac{1}{2}$ feet in diameter at the base. The Process depends upon the property of the arsenious acid to sublime before it melts. The heat sublimes the arsenious acid which melts and settles on the hot walls of these covers. When so much has collected there that the gases can no longer find egress to the chimney, the covers are taken off, and the "White Glass" knocked out of them and packed in kegs or barrels lined with paper. Only a small portion of the arsenious acid escapes into the chimney. The impurities remain behind in the botttom of the kettle.

The least admixture of soot or sulphur causes rough and streaky glass. The sublimation point of arsenious acid is somewhere about 230° C.

Manufacture of Red Glass.

The ores containing arsenical and iron pyrites are used in the process. The percentage of arsenic varies from 10 to 12 p. c.

The ore is *distilled* in clay retorts similar to those employed in the manufacture of illuminating gas. The sulphide of arsenic sublimed by the fire of stone coal beneath the retorts, deposits in boxes of sheet iron inserted into the small ends of the retorts, partly as powder and partly in a melted state.

The residue which remains in the retort contains very little arsenic, but consists principally of a magnetic sulphide of iron somewhat like magnetic pyrites. It is broken into small pieces, and delivered to the sulphuric acid works to be used in making sulphuric acid. The arsenic collected in the iron boxes is a heterogeneous and variously colored mass, possessing a stony appearance on fresh surfaces of fracture.

In order to convert the material into "Red Glass" it is first purified by melting it up in cast-iron kettles, and

stirring it thoroughly when in a liquid state by means of iron rods in order to bring the impurities to the surface, whence they can be removed.

The desired shade of color is then obtained by adding either sulphur or metallic arsenic.

By adding sulphur the color is made a darker red, and by arsenic a brighter red. On cooling, this material forms a homogeneous mass of cherry red color. In general terms it may be stated to be a sulphide of arsenic, in which the percentges of the component elements vary according to circumstances.

This "Red Glass" is known in the arts as Realgar, and is worth from 12 to 15 Thalers ($9 to 11.25) per cent.

It is used by tanners to remove the hair from the hides.

"Yellow Glass" is also a sulphide of arsenic with a higher percentage of sulphur, and is prepared in a similar manner.

ARTICLE IV.

THE ARAWACK LANGUAGE OF GUIANA IN ITS LINGUISTIC AND ETHNOLOGICAL RELATIONS.

BY D. G. BRINTON, M. D.

Read Aug. 10, 1870.

The Arawacks are a tribe of Indians who at present dwell in British and Dutch Guiana, between the Corentyn and Pomeroon rivers. They call themselves simply *lukkunu*, men, and only their neighbors apply to them the contemptuous name *aruac* (corrupted by Europeans into Aroaquis, Arawaaks, Aroacos, Arawacks, etc.), meal-eaters, from their peaceful habit of gaining an important article of diet from the amylaceous pith of the *Mauritia flexuosa* palm, and the edible root of the cassava plant.

They number only about two thousand souls, and may seem to claim no more attention at the hands of the ethnologist than any other obscure Indian tribe. But if it can be shown that in former centuries they occupied the whole of the West Indian archipelago to within a few miles of the shore of the northern continent, then on the question whether their affiliations are with the tribes of the northern or southern mainland, depends our opinion of the course of migration of the primitive inhabitants of the western world. And if this is the tribe whose charming simplicity Columbus and Peter Martyr described in such poetic language, then the historian will acknowledge a desire to acquaint himself more closely with its past and its present. It is my intention to show that such was their former geographical position.

While in general features there is nothing to distinguish them from the red race elsewhere, they have strong national traits. Physically they are rather undersized, averaging not over five feet four inches in height, but strong-limbed, agile, and symmetrical. Their foreheads are low, their noses more allied to the Aryan types than usual with their race, and their skulls of that form defined by craniologists as orthognathic brachycephalic.

From the earliest times they have borne an excellent character. Hospitable, peace-loving, quick to accept the humbler arts of civilization and the simpler precepts of Christianity, they have ever offered a strong contrast to their neighbors, the cruel and warlike Caribs. They are not at all prone to steal, lie, or drink, and their worst faults are an addiction to blood-revenge, and a superstitious veneration for their priests.

They are divided into a number of families, over fifty in all, the genealogies of which are carefully kept in the female line, and the members of any one of which are forbidden to intermarry. In this singular institution they resemble many other native tribes.

LANGUAGE.

The earliest specimen of their language under its present name is given by Johannes de Laet in his *Novus Orbis, seu Descriptio Indiæ Occidentalis* (Lugd. Bat. 1633). It was obtained in 1598. In 1738 the Moravian brethren founded several missionary stations in the country, but owing to various misfortunes, the last of their posts was given up in 1808. To them we owe the only valuable monuments of the language in existence.

Their first instructor was a mulatto boy, who assisted them in translating into the Arawack a life of Christ. I cannot learn that this is extant. Between 1748 and 1755 one of the missionaries, Theophilus Schumann, composed a dictionary, *Deutsch-Arawakisches Wœrterbuch*, and a grammar, *Deutsch-Arawakische Sprachlehre*, which have remained

in manuscript in the library of the Moravian community at Paramaribo. Schumann died in 1760, and as he was the first to compose such works, the manuscript dictionary in the possession of Bishop Wullschlägel, erroneously referred by the late Professor von Martius to the first decade of the last century, is no doubt a copy of Schumann's.

In 1807 another missionary, C. Quandt, published a *Nachricht von Surinam*, the appendix to which contains the best published grammatical notice of the tongue. The author resided in Surinam from 1769 to 1780.

Unquestionably, however, the most complete and accurate information in existence concerning both the verbal wealth and grammatical structure of the language, is contained in the manuscripts of the Rev. Theodore Schultz, now in the library of the AMERICAN PHILOSOPHICAL SOCIETY. Mr. Shultz was a Moravian missionary, who was stationed among the Arawacks from 1790 to 1802, or thereabout. The manuscripts referred to are a dictionary and a grammar. The former is a quarto volume of 622 pages. The first 535 pages comprise an Arawack-German lexicon, the remainder is an appendix containing the names of trees, stars, birds, insects, grasses, minerals, places, and tribes. The grammar, *Grammattikalische Sätze von der Aruwakkischen Sprache*, is a 12mo volume of 173 pages, left in an unfinished condition. Besides these he left at his death a translation of the Acts of the Apostles, which was published in 1850 by the American Bible Society under the title *Act Apostelnu*. It is from these hitherto unused sources that I design to illustrate the character of the language, and study its former extension. [1]

PHONETICS.

The Arawack is described as "the softest of all the Indian tongues." [2] It is rich in vowels, and free from gutturals. The enunciation is distinct and melodious. As it has been reduced to writing by Germans, the German value must be given to the letters employed, a fact which must always be borne in mind in comparing it with the neighboring tongues, nearly all of which are written with the Spanish orthography.

The Arawack alphabet has twenty letters: a, b, d, e, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, w.

Besides these, they have a semi-vowel written $\frac{l}{r}$, the sound of which in words of the masculine gender approaches l, in those of the neuter gender r. The o and u, and the t and d, are also frequently blended. The w has not the German but the soft English sound, as in *we*. The German dipthongs æ, œ, eu, ei, ü, are employed. The accents are the long ¯, the acute `, and that indicating the emphasis ´. The latter is usually placed near the commencement of the word, and must be carefully observed.

NOUNS.

Like most Indians, the Arawack rarely uses a noun in the abstract. An object in his mind is always connected with some person or thing, and this connection is signified by an affix, a suffix, or some change in the original form of the word. To this rule there are some exceptions, as *bahü* a house, *siba* a stone, *hiäru* a woman. *Dáddikân hiäru*, I see a woman. Such nouns are usually roots. Those derived from verbal roots are still more rarely employed independently.

NUMBERS. The plural has no regular termination. Often the same form serves for both numbers, as is the case in many English words. Thus, *itime* fish and fishes, *siba* stone and stones, *känsiti* a lover and lovers. The most common plural endings are *ati*, *uti*, and *anu*, connected to the root by a euphonic letter; as *uju* mother, *ujunuti* mothers, *itti* father, *ittinati* fathers, *kansissia* a loved one, *kansissiannu* loved ones.

Of a dual there is no trace, nor does there seem to be of what is called the American plural (exclusive or inclusive of those present). But there is a peculiar plural form with a singular signification in the language, which is

[1] Since reading this article before the Society, Prof. S. S. Haldeman has shown me a copy of a work with the title: "*Die Geschichte von der Marterwoche, Auferstehung und Himmelfahrt unsers Herrn und Heilandes Jesu Christi. Uebersetzt in die Aruwackische Sprache und erklärend umschrieben. Philadelphia: Gedruckt bey Carl List*, 1799," 8vo, pages 213, then one blank leaf, then 40 pages of "Anmerkungen." There is also a second title, in Arawack, and neither title page is included in the pagination. The Arawack title begins: "*Wadaijahun Wüssada-goanti, Wappussida-goanti baddia Jesus Christus*," etc. The remarks at the end are chiefly grammatical and critical, and contain many valuable hints to the student of the language. I have no doubt this book is the Life of Christ mentioned in the text. The name of the translator or editor is nowhere mentioned, but I have no doubt Mr. Schultz wrote the "Anmerkungen," and read the proof, as not only are his grammatical signs and orthography adopted throughout, but also we know from other sources that he was in Philadelphia at that time.

[2] Brett, *The Indian Tribes of Guiana*, p. 117 (London, 1868).

worthy of note. An example will illustrate it; *itti* is father, plural *ittinati; wattinati* is our father, not our fathers, as the form would seem to signify. In other words, singular nouns used with plural pronouns, or construed with several other nouns, take a plural form. *Petrus Johannes mutti ujānatu*, the mother of Peter and John.

GENDERS. A peculiarity, which the Arawack shares with the Iroquois[3] and other aboriginal languages of the Western continent, is that it only has two genders, and these not the masculine and feminine, as in French, but the masculine and neuter. Man or nothing was the motto of these barbarians. Regarded as an index of their mental and social condition, this is an ominous fact. It hints how utterly destitute they are of those high, chivalric feelings, which with us centre around woman.

The termination of the masculine is *i*, of the neuter *u*, and, as I have already observed, a permutation of the semi-vowels *l* and *r* takes place, the letter becoming *l* in the masculine, *r* in the neuter. A slight difference in many words is noticeable when pronounced by women or by men. The former would say *keretin*, to marry; the latter *kerejun*. The gender also appears by more than one of these changes: *ipillin*, great, strong, masculine; *ipirrun*, feminine and neuter.

There is no article, either definite or indefinite, and no declension of nouns.

PRONOUNS.

The demonstrative and possessive personal pronouns are alike in form, and, as in other American languages, are intimately incorporated with the words with which they are construed. A single letter is the root of each: *d* I, mine, *b* thou, thine, *l* he, his, *t* she, her, it, its, *w* we, our, *h* you, your, *n* they, their; to these radical letters the indefinite pronoun *ükküahü*, somebody, is added, and by abbreviation the following forms are obtained, which are those usually current:

dakia, dai,	I.
bokkia, bui,	thou.
likia,	he.
turreha,	she, it.
wakia, wai,	we.
hukia, hui,	you.
nakia, nai,	they.

Except the third person, singular, they are of both genders. In speaking, the abbreviated form is used, except where for emphasis the longer is chosen.

In composition they usually retain their first vowel, but this is entirely a question of euphony. The methods of their employment with nouns will be seen in the following examples:

üssiquahü,	a house.
dássiqua,	my house.
bússiqua,	thy house.
lüssiqua,	his house.
tüssiqua,	her, its house.
wássiqua,	our house.
hüssiqua,	your house.
nássiqua,	their house.
uju,	mother.
daiju,	my mother.
buju,	thy mother.

[3] *Etudes Philologiques sur quelquee Langues Sauvages de l'Amerique*, p. 87 (Montreal, 1866).

luju,	his mother.
tuju,	her mother.
waijunattu,	our mother.
hujuattu,	your mother.
naijattu,	their mother.
waijunuti,	our mothers.
hujunuti,	your mothers.
naijunuti,	their mothers.

Many of these forms suffer elision in speaking. *Itti* father, *datti* my father, *wattínatti* our father, contracted to *wattínti* (*watti* rarely used).

When thus construed with pronouns, most nouns undergo some change of form, usually by adding an affix; *báru* an axe, *dábarun* my axe, *iulí* tobacco, *dajulite* my tobacco.

ADJECTIVES.

The verb is the primitive part of speech in American tongues. To the aboriginal man every person and object presents itself as either doing or suffering something, every quality and attribute as something which is taking place or existing. His philosophy is that of the extreme idealists or the extreme materialists, who alike maintain that nothing *is*, beyond the cognizance of our senses. Therefore his adjectives are all verbal participles, indicating a state of existence. Thus *üssatu* good, is from *üssân* to be good, and means the condition of being good, a good woman or thing, *üssati* a good man.

Some adjectives, principally those from present participles, have the masculine and neuter terminations *i* and *u* in the singular, and in the plural *i* for both genders. Adjectives from the past participles end in the singular in *issia* or *üssia*, in the plural in *annu*. When the masculine ends in *illi*, the neuter takes *urru*, as *wadikilli*, *wadikurru*, long.

Comparison is expressed by adding *bén* or *kén* or *adin* (a verb meaning to be above) for the comparative, and *apüdi* for the diminutive. *Ubura*, from the verb *übürau* to be before in time, and *adiki*, from *adikin* to be after in time, are also used for the same purpose. The superlative has to be expressed by a circumlocution; as *tumaqua aditu ipirrun turreha*, what is great beyond all else; *bokkia üssá dáuria*, thou art better than I, where the last word is a compound of *dai uwúria* of, from, than. The comparative degree of the adjectives corresponds to the intensive and frequentative forms of the verbs; thus *ipirrun* to be strong, *ipirru* strong, *ipirrubín* and *ipirrubessabun* to be stronger, *ipirrubetu* and *ipirrubessabutu* stronger, that which is stronger.

The numerals are wonderfully simple, and well illustrate how the primitive man began his arithmetic. They are:—

1 abba.
2 biama, plural biamannu.
3 kabbuhin, plural kubbuhinínnu.
4 bibiti, plural bibitinu.
5 abbatekkábe, plural abbatekabbunu.
6 abbatiman, plural abbatimannínu.
7 biamattiman, plural biamattimannínu.
8 kabbuhintiman, plural kabbuhintimannínu.
9 bibitiman, plural bibititumannínu.
10 biamantekábbe, plural biamantekábunu.

Now if we analyze these words, we discover that *abbatekkábe* five, is simply *abba* one, and *akkabu* hand; that the word for six is literally "one [finger] of the other [hand]," for seven "two [fingers] of the other [hand]," and so

on to ten, which is compounded of *biama* two, and *akkabu* hands. Would they count eleven, they say *abba kutihibena* one [toe] from the feet, and for twenty the expression is *abba lukku* one man, both hands and feet. Thus, in truth, they have only four numerals, and it is even a question whether these are primitive, for *kabbuhin* seems a strengthened form of *abba*, and *bibuti* to bear the same relation to *biama*. Therefore we may look back to a time when this nation knew not how to express any numbers beyond one and two.

Although these numbers do not take peculiar terminations when applied to different objects, as in the languages of Central America and Mexico, they have a great variety of forms to express the relationship in which they are used. The ordinals are:

atenennuati,	first.
ibiamattéti,	second.
wakábbuhinteti,	our third, etc.

To the question, How many at a time? the answer is:

likinnekewai,	one alone.
biamanuman,	two at a time, etc.

If simply, How many? it is:

abbahu,	one.
biamahu,	two.

If, For which time? it is:

tibíakuja,	for the first time.
tibíamattétu,	for the second time.

and so on.

VERBS.

The verbs are sometimes derived from nouns, sometimes from participles, sometimes from other verbs, and have reflexive, passive, frequentative, and other forms. Thus from *lana*, the name of a certain black dye, comes *lannatün* to color with this dye, *alannatunna* to color oneself with it, *alannattukuttun* to let oneself be colored with it, *alanattukuttunnua* to be colored with it.

The infinitive ends in *ín*, *ün*, *ùn*, *ân*, *unnua*, *én*, and *ûn*. Those in *ín*, *ün*, *ùn*, and *ân* are transitive, in *unnua* are passive and neuter, the others are transitive, intransitive, or neuter.

The passive voice is formed by the medium of a verb of permission, thus:

amalitin,	to make.
amalitikittin,	to let make.
amalitikittunnua,	to be made.
assimakin,	to call.
assimakuttün,	to let call.
assimakuttùnnua,	to be called.

The personal pronouns are united to the verbs as they are to the nouns. They precede all verbs except those whose infinitives terminate in *én*, *in*, and *ân*, to which they are suffixed as a rule, but not always. When they follow the verb, the forms of the pronouns are either *de*, *bu*, *i* he, *n* she, it, *u*, *hu*, *je* or *da*, *ba*, *la*, *ta*, *wa*, *ha*, *na*. The latter are used chiefly where the negative prefix *m*, *ma* or *maya* is employed. Examples:

hallikebben, to rejoice.

hallikebbéde,	I rejoice.
hallikebbébu,	thou rejoicest.

hallikebbćі,	he rejoices.
hallikebbèn,	she rejoices.
hallikebbću,	we rejoice.
hallikebbćhü,	you rejoice.
hallikebbćje,	they rejoice.

majauquan, to remain.

majáuquada,	I remain.
majáuquaba,	thou remainest.
majáuquala,	he remains.
majáuquȧta,	she remains.
majáuquawa,	we remain.
majáuquaha,	you remain.
majáuquana,	they remain.

Moods and Tenses. Their verbs have four moods, the indicative, optative, imperative, and infinitive, and five tenses, one present, three preterites, and one future. The rules of their formation are simple. By changing the termination of the infinitive into *a*, we have the indicative present, into *bi* the first preterite, into *buna* the second preterite, into *kuba* the third preterite, and into *pa* the future. The conjugations are six in number, and many of the verbs are irregular. The following verb of the first conjugation illustrates the general rules for conjugation:

ayahaddin, to walk.

Indicative Mood.

Present tense:

dayahadda,	I walk.
bujahadda,	thou walkest.
lujahadda,	he walks.
tüjahadda,	she walks.
wayahádda,	we walk.
hujahádda,	you walk.
nayuhádda,	they walk.

First preterite—of to-day:

dayaháddibi,	I walked to-day.
bujaháddibi,	thou walked to-day.
lijaháddibi,	he walked to-day.
tujaháddibi,	she walked to-day.
wayaháddibi,	we walked to-day.
hujaháddibi,	you walked to-day.
nayaháddibi,	they walked to-day.

Second preterite—of yesterday or the day before.

dayahaddibüna,	I walked yesterday or the day before.
bujaháddibüna,	thou walked yesterday or the day before.
lijaháddibuna,	he walked yesterday or the day before.
tujaháddibüna,	she walked yesterday or the day before.
wayaháddibüna,	we walked yesterday or the day before.
hujaháddibüna,	you walked yesterday or the day before.
nayaháddibüna,	they walked yesterday or the day before.

Third preterite—at some indefinite past time:

dayahâddakuba,	I walked.
bujahâddakuba,	thou walked.
lijahâddakuba,	he walked.
tujahâddakuba,	she walked.
wayahâddakuka,	we walked.
hujahâddakuba,	you walked.
nayahâddakuba,	they walked.

Future:

dayahâddipa,	I shall walk.
bujahâddipa,	thou wilt walk.
lijahâddipa,	he will walk.
tujahâddipa,	she will walk.
wayahâddipa,	we shall walk.
hujahaddipa,	you will walk.
nayahaddipa,	they will walk.

OPTATIVE MOOD.

Present:

dayahaddama or dayahaddinnika, — I may walk.

First preterite:

dayahaddinnikâbima.

Second preterite

dayahaddinbünáma.

Third preterite:

dayahaddinnikubáma.

IMPERATIVE MOOD.

bujahaddâte or bujahaddalte,	walk thou.
hüjahaddâte or hujahaddalte,	walk ye.
nayahaddâte,	let them walk.
wayahaddali,	let us walk.

PARTICIPLES.

ayahaddinnibi,	to have walked to-day.
ayahaddinnibüna,	to have walked yesterday.
ayahaddínnikuba,	to have walked.
ayahaddínnipa,	to be about to walk.

GERUND.

ayahaddinti.
ayahaddinnibia.

The following forms also belong to this verb:

ayahaddinnibiakubáma,	to may or can walk.
ayahaddahálin,	one who walks there (infinitive form).

As in all polysynthetic languages, other words and particles can be incorporated in the verb to modify its meaning, thus:

dayahaddáruka,	as I was walking.
dayahaddakanika,	I walk a little.
dayahaddahittika,	I walk willingly.

In this way sometimes words of formidable length are manufactured, as:

massukussukuttunnuanikaebibu, you should not have been washed to-day.

Negation may be expressed either by the prefix *m* or *ma*, as *mayahaddinikade*, I do not walk (where the prefix throws the pronoun to the end of the word, and gives it the form appropriate for that position), or else by the adverb *kurru*, not. But if both these negatives are used, they make an affirmative, as *madittinda kurru Gott*, I am not unacquainted with God.

COMPOSITION OF WORDS AND SENTENCES.

"In general," remarks Prof. Von Martius, "this language betrays the poverty and cumbrousness of other South American languages; yet in many expressions a glimpse is caught of a far reaching, ideal background."[4] We see it in the composition and derivation of some words; from *haikan* to pass by, comes *haikahu* death, the passing away, and *aiihakü* marriage, in which, as in death, the girl is lost to her parents; from *kassan* to be pregnant, comes *kassaku* the firmament, big with all things which are, and *kassahu behü*, the house of the firmament, the sky, the day; from *ükkü* the heart, comes *ükkürahü* the family, the tribe, those of one blood, whose hearts beat in unison, and *üküahü* a person, one whose heart beats and who therefore lives, and also, singularly enough, *ükkürahü* pus, no doubt from that strange analogy which in so many other aboriginal languages and myths identified the product of suppuration with the *semen masculinum*, the physiological germ of life.

The syntax of the language is not clearly set forth by any authorities. Adjectives generally, but not always, follow the words they qualify, and prepositions are usually placed after the noun, and often at the end of a sentence; thus, *peru* (Spanish *perro*) *assimakaka naha à*, the dog barks her at. To display more fully the character of the tongue, I shall quote and analyze a verse from the *Act Apostelnu*, the 11th verse of the 14th chapter, which in the English Protestant version reads:

And when the people saw what Paul had done, they lifted up their voices, saying in the speech of Lycaonia, The gods are come down to us in the likeness of men.

In Arawack it is:

Addikitti uijuhu Paulus anissiäbiru, kakannaküku na assimakâka hürküren Lycaonia adiân ullukku hiddin: Amallitakoanauutti lukkunu dia na buté wakkarruhu, nattukuda aijumüneria wibiti hinna.

Literally:

They—seeing (*addin* to see, gerund) the—people Paulus what—had been done (*anin* to do, *anissia* to have been done), loudly they called altogether the—Lycaonia speech in, thus, The—gods (present participle of *amallitin* to make; the same appellation which the ancient Greeks gave to poets, ποιηταί makers, the Arawacks applied to the divine powers) men like, us to now (*buté* nota præsentis) are—come—down from—above—down—here ourselves because—of.

AFFILIATIONS OF THE ARAWACK.

The Arawacks are essentially of South American origin and affiliations. The earliest explorers of the mainland report them as living on the rivers of Guiana, and having settlements even south of the Equator.[5] De Laet in his map of Guiana locates a large tribe of "Arowaccas" three degrees south of the line, on the right bank of the Amazon. Dr. Spix during his travels in Brazil met with fixed villages of them near Fonteboa, on the river Solimoes and near Tabatinga and Castro d'Avelaes.[6] They extended westward beyond the mouth of the Orinoco, and we even hear of them in the province of Santa Marta, in the mountains south of Lake Maracaybo.[7]

While their language has great verbal differences from the Tupi of Brazil and the Carib, it has also many verbal

[4] *Beiträge zur Ethnographie und Sprachenkunde Amerika's zumal Brasiliens*, B. I., p. 705 (Leipzig, 1867).

[5] De Laet, *Novus Orbis*, lib. xvii., cap. vi.

[6] Martius, *Ethnographie und Sprachenkunde Amerika's*, B. I., S. 687.

[7] Antonio Julian, *La Perla de la America, la Provincia de Santa Marta*, p. 149.

similarities with both. "The Arawack and the Tupi," observes Professor Von Martius, "are alike in their syntax, in their use of the possessive and personal pronouns, and in their frequent adverbial construction;" [8] and in a letter written me shortly before his death, he remarks, in speaking of the similarity of these three tongues: "Ich bin überzeugt dass diese [die Cariben] eine Elite der Tupis waren, welche erst spät auf die Antillen gekommen sind, wo die alte Tupi—Sprache in kaum erkennbaren Resten übrig war, als man sie dort aufzeichnete." I take pleasure in bringing forward this opinion of the great naturalist, not only because it is not expressed so clearly in any of his published writings, but because his authority on this question is of the greatest weight, and because it supports the view which I have elsewhere advanced of the migrations of the Arawack and Carib tribes.[9] These "hardly recognizable remains of the Tupi tongue," we shall see belonged also to the ancient Arawack at an epoch when it was less divergent than it now is from its primitive form. While these South American affinities are obvious, no relationship whatever, either verbal or syntactical, exists between the Arawack and the Maya of Yucatan, or the Chahta-Muskoki of Florida and the northern shore of the Gulf of Mexico.

As it is thus rendered extremely probable that the Arawack is closely connected with the great linguistic families of South America, it becomes of prime importance to trace its extension northward, and to determine if it is in any way affined to the tongues spoken on the West India Islands, when these were first discovered.

The Arawacks of to-day when asked concerning their origin point to the north, and claim at some not very remote time to have lived at *Kairi*, an island, by which generic name they mean Trinidad. This tradition is in a measure proved correct by the narrative of Sir Walter Raleigh, who found them living there in 1595,[10] and by the Belgian explorers who in 1598 collected a short vocabulary of their tongue. This oldest monument of the language has sufficient interest to deserve copying and comparing with the modern dialect. It is as follows:

LATIN.	ARAWACK, 1598.	ARAWACK, 1800.
pater,	pilplii,	itti.
mater,	saeckee,	uju.
caput,	wassijehe,	waseye.
auris,	wadycke,	wadihy.
oculus,	wackosije,	wakusi.
nasus,	wassyerii,	wasiri.
os,	dalerocke,	daliroko.
dentes,	darii,	dari.
crura,	dadane,	dadaanah.
pedes,	dackosye,	dakuty.
arbor,	hada,	adda.
arcus,	semarape,	semaara-haaba.
sagittæ,	symare,	semaara.
luna,	cattehel,	katsi.
sol,	adaly,	hadalli.

The syllables *wa* our, and *da* my, prefixed to the parts of the human body, will readily be recognized. When it is remembered that the dialect of Trinidad no doubt differed slightly from that on the mainland; that the modern orthography is German and that of De Laet's list is Dutch; and that two centuries intervened between the first and second, it is really a matter of surprise to discover such a close similarity. Father and mother, the only two words which are not identical, are doubtless different expressions, relationship in this, as in most native tongues, being indicated with excessive minuteness.

The chain of islands which extend from Trinidad to Porto Rico were called, from their inhabitants, the Caribby islands. The Caribs, however, made no pretence to have occupied them for any great length of time. They dis-

[8] *Ethnographie, etc.*, B. I., S. 714.

[9] *The Myths of the New World; a Treatise on the Symbolism and Mythology of the Red Race of America*, p. 32 (New York, 1868).

[10] *The Discoverie of Guiana*, p 4 (Hackluyt, Soc., London, 1842).

tinctly remembered that a generation or two back they had reached them from the mainland, and had found them occupied by a peaceful race, whom they styled *Ineri* or *Igneri*. The males of this race they slew or drove into the interior, but the women they seized for their own use. Hence arose a marked difference between the languages of the island Caribs and their women. The fragments of the language of the latter show clearly that they were of Arawack lineage, and that the so-called Igneri were members of that nation. It of course became more or less corrupted by the introduction of Carib words and forms, so that in 1674 the missionary De la Borde wrote, that "although there is some difference between the dialects of the men and women, they readily understand each other;" [11] and Father Breton in his Carib Grammar (1665) gives the same forms for the declensions and conjugations of both.

As the traces of the "island Arawack," as the tongue of the Igneri may be called, prove the extension of this tribe over all the Lesser Antilles, it now remains to inquire whether they had pushed their conquests still further, and had possessed themselves of the Great Antilles, the Bahama islands, and any part of the adjacent coasts of Yucatan or Florida.

All ancient writers agree that on the Bahamas and Cuba the same speech prevailed, except Gomara, who avers that on the Bahamas "great diversity of language" was found.[12] But as Gomara wrote nearly half a century after those islands were depopulated, and has exposed himself to just censure for carelessness in his statements regarding the natives,[13] his expression has no weight. Columbus repeatedly states that all the islands had one language though differing, more or less, in words. The natives he took with him from San Salvador understood the dialects in both Cuba and Haiti. One of them on his second voyage served him as an interpreter on the southern shore of Cuba.[14]

In Haiti, there was a tongue current all over the island, called by the Spaniards *la lengua universal* and *la lengua cortesana*. This is distinctly said by all the historians to have been but very slightly different from that of Cuba, a mere dialectic variation in accent being observed.[15] Many fragments of this tongue are preserved in the narratives of the early explorers, and it has been the theme for some strange and wild theorizing among would-be philologists. Rafinesque christened it the "Taino" language, and discovered it to be closely akin to the "Pelasgic" of Europe.[16] The Abbé Brasseur de Bourbourg will have it allied to the Maya, the old Norse or Scandinavian, the ancient Coptic, and what not. Rafinesque and Jegor von Sivors[17] have made vocabularies of it, but the former in so uncritical, and the latter in so superficial a manner, that they are worse than useless.

Although it is said there were in Haiti two other tongues in the small contiguous provinces of Macorix de arriba and Macorix de abajo, entirely dissimilar from the *lengua universal* and from each other, we are justified in assuming that the prevalent tongue throughout the whole of the Great Antilles and the Bahamas, was that most common in Haiti. I have, therefore, perused with care all the early authorities who throw any light upon the construction and vocabulary of this language, and gathered from their pages the scattered information they contain. The most valuable of these authorities are Peter Martyr de Angleria, who speaks from conversations with natives brought to Spain by Columbus, on his first voyage,[18] and who was himself, a fine linguist, and Bartolomé de las Casas. The latter came as a missionary to Haiti, a few years after its discovery, was earnestly interested in the natives, and to some extent acquainted with their language. Besides a few printed works of small importance, Las Casas left two large and valuable works in manuscript, the *Historia General de las Indias Occidentales*, and the *Historia Apologetica de las Indias Occidentales*. A copy of these, each in four large folio volumes, exists in the Library of Congress, where I

[11] *Relation de l'Origine, etc., des Caraibes*, p. 39 (Paris, 1674).

[12] "Havia mas policia entre ellos [los Lucayos,] i mucha diversidad de Lenguas." *Hist. de las Indias*, cap. 41.

[13] Las Casas, in the *Historia General de las Indias Occid*, lib. III, cap. 27, criticizes him severely.

[14] Columbus says of the Bahamas and Cuba: "toda la lengua es una y todos amigos" (Navarrete, *Viages*, Tomo I, p. 46.) The natives of Guanahani conversed with those of Haiti "porque todos tenian una lengua," (*ibid*, p. 86.) In the Bay of Samana a different dialect but the same language was found (p, 135).

[15] Gomara says the language of Cuba is "algo diversa," from that of Espanola. (*Hist. de las Indias*, cap, 41.) Oviedo says that though the natives of the two islands differ in many words, yet they readily understand each other. (*Hist. de las Indias*, lib. XVII, cap. 4.)

[16] The American Nations, chap. VII, (Philadelphia, 1836.)

[17] *Cuba, die Perle der Antillen*, p. 72. (Leipzig, 1851.) The vocabulary contains 33 words, "*aus dem Cubanischen.*" Many are incorrect both in spelling and pronunciation.

[18] When Columbus returned from his first voyage, he brought with him ten natives from the Bay of Samana in Hayti, and a few from Guanahani.

consulted them. They contain a vast amount of information relating to the aborigines, especially the *Historia Apologetica*, though much of the author's space is occupied with frivolous discussions and idle comparisons.

In later times, the scholar who has most carefully examined the relics of this ancient tongue, is Señor Don Estevan Richardo, a native of Haiti, but who for many years resided in Cuba. His views are contained in the preface to his *Diccionario Provincial casi-razonado de Voces Cubanas*, (Habana, 2da ed, 1849). He has found very many words of the ancient language retained in the provincial Spanish of the island, but of course in a corrupt form. In the vocabulary which I have prepared for the purpose of comparison, I have omitted all such corrupted forms, and nearly all names of plants and animals, as it is impossible to identify these with certainty, and in order to obtain greater accuracy, have used, when possible, the first edition of the authors quoted, and in most instances, given under each word a reference to some original authority.

From the various sources which I have examined, the alphabet of the *lengua universal* appears to have been as follows: a, b, d, e, (rarely used at the commencement of a word), g, j, (an aspirated guttural like the Catalan j, or as Peter Martyr says, like the Arabic ch), i (rare), l (rare), m, n, o (rare,) p, q, r, s, t, u, y. These letters, it will be remembered, are as in Spanish.

The Spanish sounds z, ce, ci (English th,) ll, and v, were entirely unknown to the natives, and where they appear in indigenous words, were falsely written for l and b. The Spaniards also frequently distorted the native names by writing x for j, s, and z, by giving j the sound of the Latin y, and by confounding h, j, and f, as the old writers frequently employ the h to designate the *spiritus asper*, whereas in modern Spanish it is mute.[19]

Peter Martyr found that he could reduce all the words of their language to writing, by means of the Latin letters without difficulty, except in the single instance of the guttural j. He, and all others who heard it spoken, describe it as "soft and not less liquid than the Latin," "rich in vowels and pleasant to the ear," an idiom "simple, sweet, and sonorous."[20]

In the following vocabulary I have not altered in the least the Spanish orthography of the words, and so that the analogy of many of them might at once be preceived, I have inserted the corresponding Arawack expression, which, it must be borne in mind, is to be pronounced by the German alphabet.

Vocabulary of the Ancient Language of the Great Antilles.

Aji, red pepper. Arawack, *achi*, red pepper.

Aon, dog (Las Casas, Hist. Gen. lib. I, c. 120). Island Ar. *ánli*, dog.

Arcabuco, a wood, a spot covered with trees (Oviedo, Hist. Gen. de las Indias, lib. VI, c, 8). Ar. *arragkaragkadin* the swaying to and fro of trees.

Areito, a song chanted alternately by the priests and the people at their feasts. (Oviedo, Hist. Gen. lib. V, c. 1.) Ar. *aririn* to name, rehearse.

Bagua, the sea. Ar. *bara*, the sea.

Bajaraque, a large house holding several hundred persons. From this comes Sp. *barraca*, Eng. *barracks*. Ar. *bajü*, a house.

Bajari, title applied to sub-chiefs ruling villages, (Las Casas, Hist. Apol. cap. 120). Probably "house-ruler," from Ar. *bajü*, house.

Barbacoa, a loft for drying maize, (Oviedo, Hist. Gen. lib. VII, cap. 1). From this the English barbacue. Ar. *barrabakoa*, a place for storing provisions.

[19] See the remarks of Richardo in the Prologo to his *Diccionario Provincial*.

[20] The remarks of Peter Martyr are; "posse omnium illarum linguam nostris literis Latinis, sine ullo discrimine, scribi compertum est," (*De Rebus Oceanicis et Novo Orbe*, Decades Tres, p. 9.) "Advertendum est, nullam inesse adspirationem vocabulis eorum, quae non habeat effectum literae consonantis; immo gravius adspirationem proferunt, quam nos f consonantem. Proferendumque est quicquid est adspiratum eodum halitu quo f, sed minime admoto ad superiores dentes inferiore labello, ore aut aperto ha, he, hi, ho, hu, et concusso pectore. Hebraeos et Arabicos eodem modo suas proferre adspirationes vides," (id. pp. 285, 286.)

Batay, a ball-ground; bates, the ball; batey, the game. (Las Casas, Hist. Apol. c. 204). Ar. *battatan*, to be round, spherical.[21]

Batea, a trough. (Las Casas, Hist. Apol. c. 241.)

Bejique, a priest. Ar. *piaye*, a priest.

Bixa, an ointment. (Las Casas, Hist. Apol. cap. 241.)

Cai, cayo, or cayco, an island. From this the Sp. *cayo*, Eng. *key*, in the "Florida keys." Ar. *kairi*, an island.

Caiman, an alligator, Ar. *kaiman*, an alligator, lit. to be strong.

Caona or cáuni, gold. (Pet. Martyr, Decad. p. 26, Ed. Colon, 1564). Ar. *kaijaunan*, to be precious, costly.

Caracol, a conch, a univalve shell. From this the Sp. *caracol*. (Richardo, Dicc. Provin. s. v). Probably from Galibi *caracoulis*, trifles, ornaments. (See Martius, Sprachenkunde, B. II, p. 332.)

Caney or cansi, a house of conical shape.

Canoa, a boat. From this Eng. *canoe*. Ar. *kannoa*, a boat.

Casique, a chief. This word was afterwards applied by Spanish writers to the native rulers throughout the New World. Ar. *kassiquan* (from *ussequa*, house), to have or own a house or houses; equivalent, therefore, to the Eng. landlord.

Cimu or simu, the front, forehead; a beginning. (Pet. Martyr, Decad. p. 302.) Ar. *eme* or *uime*, the mouth of a river, *uimelian*, to be new.

Coaibai, the abode of the dead.

Cohóba, the native name of tobacco.

Conuco, a cultivated field. (Oviedo, Hist. Gen. lib. VII, cap. 2.)

Duhos or duohos, low seats (unas baxas sillas, Las Casas, Hist. Gen. lib. I, cap 96. Oviedo, Hist. Gen. lib. V. cap. 1. Richardo, *sub voce*, by a careless reading of Oviedo says it means images). Ar. *dulluhu* or *durruhu*, a seat, a bench.

Goeiz, the spirit of the living (Pane, p. 444); probably a corruption of *Guayzas*. Ar. *akkuyaha*, the spirit of a living animal.

Gua, a very frequent prefix: Peter Martyr says, "Est apud eos articulus et pauca sunt regum praecipue nominum quae non incipiant ab hoc articulo *gua*." (Decad. p. 285.) Very many proper names in Cuba and Hayti still retain it. The modern Cubans pronounce it like the English w with the *spiritus lenis*. It is often written *oa*, *ua*, *oua*, and *hua*. It is not an article, but corresponds to the *ah* in the Maya, and the *gue* in the Tupi of Brazil, from which latter it is probably derived.[22]

Guaca, a vault for storing provisions.

Guacabina, provisions for a journey, supplies.

Guacamayo, a species of parrot, macrocercus tricolor.

Guanara, a retired stop. (Pane, p. 444); a species of dove, columba zenaida (Richardo, S. V.)

Guanin, an impure sort of gold.

Guaoxeri, a term applied to the lowest class of the inhabitants (Las Casas, Hist. Apol. cap. 197.) Ar. *wakaijaru*, worthless, dirty, *wakaijatti lihi*, a worthless fellow.

Guatiao, friend, companion (Richardo). Ar. *ahati*, companion, playmate.

Guayzas, masks or figures (Las Casas, Hist. Apol. cap. 61). Ar. *akkuyaha*, living beings.

Haba, a basket (Las Casas, Hist. Gen. lib. III, cap. 21). Ar. *habba*, a basket.

Haiti, stony, rocky, rough (Pet. Martyr, Decades). Ar. *aessi* or *aetti*, a stone.

Hamaca, a bed, hammock. Ar. *hamaha*, a bed, hammock.

Hico, a rope, ropes (Oviedo, Hist. Gen. lib. V, cap. 2).

[21] There was a ball-ground in every village. It was "tres veces mas luenga que ancha, cercada de unos lomillos de un palmo o dos de alto." The ball was "como las de viento nuestras mas no cuanto al salto, que era mayor que seis de las de viento." (Las Casas, *Historia Apologetica*, caps. 46, 204.) Perhaps the ball was of India rubber.

[22] "Gue ou Gui, signal de vocativo, mas so empregado pelos homems." Dias *Diccionario da Lingua Tupy chamada Lingua Geral dos Indigenas do Brazil*, p. 60 (Lipsia, 1858).

Hobin, gold, brass, any reddish metal. (Navarrete Viages, i, p. 134, Pet. Martyr, Dec. p. 303). Ar. *hobin*, red.

Huiho, height. (Pet. Martyr, p. 304). Ar. *aijumün*, above, high up.

Huracan, a hurricane. From this Sp. *huracan*, Fr. *ouragan*, German *Orkan*, Eng. *hurricane*. This word is given in the *Livre Sacré des Quichès* as the name of their highest divinity, but the resemblance may be accidental. Father Ximenes, who translated the *Livre Sacrè*, derives the name from the Quiché *hu rakan*, one foot. Father Thomas Coto, in his Cakchiquel Dictionary, (MS. in the library of the Am. Phil. Soc.) translates *diablo* by *hurakan*, but as the equivalent of the Spanish *huracan*, he gives *ratinchet*.

Hyen, a poisonous liquor expressed from the cassava root. (Las Casas, Hist. Apol. cap. 2).

Itabo, a lagoon, pond. (Richardo).

Juanna, a serpent. (Pet. Martyr, p. 63). Ar. *joanna*, a lizard ; *jawanaria*, a serpent.

Macana, a war club. (Navarrete, Viages. i. p. 135).

Magua, a plain. (Las Casas, Breviss. Relat. p. 7).

Maguey, a native drum. (Pet. Martyr, p. 280).

Maisi, maize. From this Eng. *maize*, Sp. *mais*, Ar. *marisi*, maize.

Matum, liberal, noble. (Pet. Martyr, p. 292).

Matunheri, a title applied to the highest chiefs. (Las Casas, Hist. Apol. cap. 197).

Mayani, of no value. ("nihili," Pet. Martyr, p. 9). Ar. *ma*, no, not.

Naborias, servants. (Las Casas, Hist. Gen. lib. III, cap. 32).

Nacan, middle, center. Ar. *annakan*, center.

Nagua, or enagua, the breech cloth made of cotton and worn around the middle. Ar. *annaka*, the middle.

Nitainos, the title applied to the petty chiefs, (regillos ò guiallos, Las Casas, Hist. Apol. cap, 197) ; *tayno* vir bonus, *taynos* nobiles, says Pet. Martyr, (Decad. p. 25). The latter truncated form of the word was adopted by Rafinesque and others, as a general name for the people and language of Hayti. There is not the slightest authority for this, nor for supposing, with Von Martius, that the first syllable is a pronominal prefix. The derivation is undoubtedly Ar. *nüddan* to look well, to stand firm, to do anything well or skilfully.

Nucay or nozay, gold, used especially in Cuba and on the Bahamas. The words *caona* and *tuob* were in vogue in Haiti (Navarrete, Viages, Tom. 1, pp. 45, 134).

Operito, dead, and

Opia, the spirit of the dead (Pane, pp. 443, 444). Ar. *aparrün* to kill, *apparahun* dead, *lupparrükittoa* he is dead.

Quisquéia, a native name of Haiti ; "vastitas et universus ac totus. Uti Græci suum Panem," says Pet. Martyr (Decad. p. 279). "Madre de las tierras," Valverde translates it (*Idea del valor de la Isla Española*, Introd. p. xviii). The orthography is evidently very false.

Sabana, a plain covered with grass without trees (terrano llano, Oviedo, Hist. Gen. lib. vi. cap. 8). From this the Sp. *savana*, Eng. *savannah*. Charlevoix, on the authority of Mariana, says it is an ancient Gothic word (Histoire de l'Isle St. Domingue, i. p. 53). But it is probably from the Ar. *sallaban*, smooth, level.

Semi, the divinities worshipped by the natives ("Lo mismo que nosotros llamamos Diablo," Oviedo, Hist. Gen. lib. v. cap. 1. Not evil spirits only, but all spirits). Ar. *semeti* sorcerers, diviners, priests.

Siba, a stone. Ar. *siba*, a stone.

Starei, shining, glowing (relucens, Pet. Martyr, Decad. p. 304). Ar. *terén* to be hot, glowing, *terehü* heat.

Tabaco, the pipe used in smoking the cohoba. This word has been applied in all European languages to the plant nicotiana tabacum itself.

Taita, father (Richardo). Ar. *itta* father, *daitta* or *datti* my father.

Taguáguas, ornaments for the ears hammered from native gold (Las Casas, Hist. Apol. cap. 199).

Tuob, gold, probably akin to *hobin*, q. v.

Turey, heaven. Idols were called "cosas de *turey*" (Navarrete, Viages, Tom. i. p. 221). Probably akin to *starei*, q. v.

The following numerals are given by Las Casas (Hist. Apol. cap. 204).

1 hequeti. Ar. *hürketai*, that is one, from *hürkün* to be single or alone.

2 yamosa. Ar. *biama*, two.

3 canocum. Ar. *kannikún*, many, a large number, *kannikukade*, he has many things.

4 yamoncobre, evidently formed from yamosa, as Ar. *bibiti*, four, from *biama*, two.

The other numerals Las Casas had unfortunately forgotten, but he says they counted by hands and feet, just as the Arawacks do to this day.

Various compound words and phrases are found in different writers, some of which are readily explained from the Arawack. Thus *tureigua hobin*, which Peter Martyr translates "rex resplendens uti orichalcum,"[23] in Arawack means "shining like something red." Oviedo says that at marriages in Cuba it was customary for the bride to bestow her favors on every man present of equal rank with her husband before the latter's turn came. When all had thus enjoyed her, she ran through the crowd of guests shouting *manícato*, *manícato*, "lauding herself, meaning that she was strong, and brave, and equal to much."[24] This is evidently the Ar. *manikade*, from *mân*, *manin*, and means I am unhurt, I am unconquered. When the natives of Haiti were angry, says Las Casas,[25] they would not strike each other, but apply such harmless epithets as *buticaco*, you are blue-eyed (anda para zarco de los ojos), *xeyticaco*, you are black-eyed (anda para negro de los ojos), or *mahite*, you have lost a tooth, as the case might be. The termination *aco* in the first two of these expressions is clearly the Ar. *acou*, or *akusi*, eyes, and the last mentioned is not unlike the Ar. *márikata*, you have no teeth (*ma* negative, *ari* tooth). The same writer gives for "I do not know," the word *ita*, in Ar. *daitta*.[26]

Some of the words and phrases I have been unable to identify in the Arawack. They are *duiheyniquen*, dives fluvius, *maguacochíos* vestiti homines, both in Peter Martyr, and the following conversation, which he says took place between one of the Haitian chieftians and his wife.

She. Teítoca teítoca. Técheta cynáto guamechyna. Guaibbá.

He. Cynáto machabuca guamechyna.

These words he translated: *teitoca* be quiet, *técheta* much, *cynato* angry, *guamechyna* the Lord, *guaibba* go, *machabuca* what is it to me. But they are either very incorrectly spelled, or are not Arawack.

The proper names of localities in Cuba, Hayti and the Bahamas, furnish additional evidence that their original inhabitants were Arawacks. Hayti, I have already shown has now the same meaning in Arawack which Peter Martyr ascribed to it at the discovery. Cubanacan, a province in the interior of Cuba, is compounded of *kuba* and *annakan*, in the center;[27] Baracoa, the name of province on the coast, is from Ar. *bara* sea, *koan* to be there, "the sea is there;" in Barajagua the *bara* again appears; Guaymaya is Ar. *waya* clay, *mara* there is none; Marien is from Ar. *maran* to be small or poor; Guaniguanico, a province on the narrow western extremity of the island, with the sea on either side, is probably Ar. *wuini wuini koa*, water, water is there. The names of tribes such as Siboneyes, Guantaneyes, owe their termination to the island Arawack, *eyeri* men, in the modern dialect *hiaeru*, captives, slaves. The Siboneyes are said by Las Casas, to have been the original inhabitants of Cuba.[28] The name is evidently from Ar. *siba*, rock, *eyeri* men, "men of the rocks." The rocky shores of Cuba gave them this appellation. On the other hand the

[23] *De Rebus Oceanicis*, p. 303.

[24] *Hist. de las Indias*, lib. xvii. cap. 4, Las Casas denies the story, and says Oviedo told it in order to prejudice people against the natives (*Hist. Gen. de las Indias*, lib. iii cap. xxiv). It is, however, probably true.

[25] *Historia Apologetica*, cap. 198.

[26] He compares the signification of *ita* in Haytian to *ita* in Latin, and translates the former *ita* by *no se;* this is plainly an error of the transcriber for *yo se* (*Hist. Apologetica*, cap. 241).

[27] *Kuba* in Arawack is the sign of past time and is used as a prefix to nouns, as well as a suffix to verbs. *Kubakanan* ancestors, those passed away, those who lived in past times.

[28] "Toda la mas de la gente de que estaba poblaba aquella isla [Cuba] era passada y natural desta ysla Espanola, puesto que la mas antigua y natural de aquella ysla era como la de los Lucayos de quien ablamos en el primero y segundo libro ser como los seres que parecia no haber pecado nuestro padre Adan en ellos, gente simplicissima, bonissima, careciente de todos vicios, y beatissima. Esta era la natural y native de aquella ysla, y llamabanse en su lengua, Ciboneyes, la penultima silaba luenga; y los desta por grado o por fuerza se apodearon de aquella ysla y gente della, y los tenian como sirvientes suyos." (Las Casas *Hist. Gen. de las Indias*, MSS. lib. iii, cap. 21). Elsewhere (cap. 23) he says this occurred "mayormente" after the Spaniards had settled in Haiti.

natives of the islets of the Bahamas were called *lukku kairi*, abbreviated to *lukkairi*, and *lucayos*, from *lukku*, man, *kairi* an island, "men of the islands;" and the archipelago itself was called by the first explorers "las islas de los Lucayos," "isole delle Lucai."[29] The province in the western angle of Haiti was styled Guacaiarima, which Peter Martyr translates "insulae podex;" dropping the article, *caiarima* is sufficiently like the Ar. *kairuina*, which signifies *podex*, Sp. *culata*, and is used geographically in the same manner as the latter word.

The word Maya frequently found in the names of places in Cuba and Haiti, as Mayaba, Mayanabo, Mayajigua, Cajimaya, Jaimayabon, is doubtless the Ar. negative *ma*, *mân*, *mara*. Some writers have thought it indicative of the extension of the Maya language of Yucatan over the Antilles. Prichard, Squier, Waitz, Brasseur de Bourbourg, Bastian and other ethnologists have felt no hesitation in assigning a large portion of Cuba and Haiti to the Mayas. It is true the first explorers heard in Cuba and Jamaica, vague rumors of the Yucatecan peninsula, and found wax and other products brought from there.[30] This shows that there was some communication between the two races, but all authorities agree that there was but one language over the whole of Cuba. The expressions which would lead to a different opinion are found in Peter Martyr. He relates that in one place on the southern shore of Cuba, the interpreter whom Columbus had with him, a native of San Salvador, was at fault. But the account of the occurrence given by Las Casas, indicates that the native with whom the interpreter tried to converse simply refused to talk at all.[31] Again, in Martyr's account of Grijalva's voyage to Yucatan in 1517, he relates that this captain took with him a native to serve as an interpreter; and to explain how this could be, he adds that this interpreter was one of the Cuban natives "quorum idioma, si non idem, consanguineum tamen," to that of Yucatan. This is a mere fabrication, as the chaplain of Grijalva on this expedition states explicitly in the narrative of it which he wrote, that the interpreter was a native of Yucatan, who had been captured a year before.[32]

Not only is there a very great dissimilarity in sound, words, and structure, between the Arawack and Maya, but the nations were also far asunder in culture. The Mayas were the most civilized on the continent, while the Arawacks possessed little besides the most primitive arts, and precisely that tribe which lived on the extremity of Cuba nearest Yucatan, the Guanataneyes, were the most barbarous on the island.[33]

The natives of the greater Antilles and Bahamas differed little in culture. They cultivated maize, manioc, yams, potatoes, corn, and cotton. The latter they wove into what scanty apparel they required. Their arms were bows with reed arrows, pointed with fish teeth or stones, stone axes, spears, and a war club armed with sharp stones called a *macana*. They were a simple hearted, peaceful, contented race, "all of one language and all friends," says Columbus; "not given to wandering, naked, and satisfied with little," says Peter Martyr; "a people very poor in all things," says Las Casas.

Yet they had some arts. Statues and masks in wood and stone were found, some of them in the opinion of Bishop Las Casas, "very skilfully carved." They hammered the native gold into ornaments, and their rude sculptures on the face of the rocks are still visible in parts of Cuba and Haiti. Their boats were formed of single trunks of trees often of large size, and they managed them adroitly; their houses were of reeds covered with palm leaves, and usually accommodated a large number of families; and in their holy places, they set up rows of large stones like the ancient cromlechs, one of which is still preserved in Hayti, and is known as *la cercada de los Indios*.

[29] "Lucayos o por mejor decir Yucayos" says Las Casas, (*Hist. Gen.* lib. ii, cap. 41) and after him Herrera. But the correction which was based apparently on some supposed connection of the word with *yuca*, the Haitian name of an esculent plant, is superfluous, and Las Casas himself never employs it, nor a single other writer.

[30] Las Casas, *Hist. Gen. de las Indias*, lib. iv. cap. 48, MSS. Bees were native to Yucatan long before the discovery, but not to the north temperate zone.

[31] "Varia enim esse idiomata in variis Cubae provinciis perpenderunt." (Pet. Martyr, *De Rebus Oceanicis*, v. 42). Las Casas says that a sailor told Columbus that he saw one Indian cacique in a long white tunic who refused to speak, but stalked silently away. (*Hist. de las Indias*, lib. I. cap. 95). Martyr says there were several. Peschel suggests they were tall white flamingoes, that scared the adventurous tar out of his wits. (*Geschichte des Zeitalters der Entdeckungen*, p. 253). At any rate the story gives no foundation at all for Peter Martyr's philogical opinion.

[32] Pet. Martyr, *De Insulis Nuper Inventis*, p. 335. "Traia consigo Grisalva un Indio per lengua de los que de aquella tierra habian llevado consigo a la ysla de Cuba Francisco Hernandez. Las Casas *Hist. Gen. de las Indias*, lib. III, cap. 108, MSS. See also the chaplain's account in Terneaux Compans, *Recueil de Pieces rel. a la Conquête de Mexique*, p. 56.

[33] Bernal Dias says the vicinity of cape San Antonio was inhabited by the "Guanataneys que son unos Indias como salvages." He expressly adds that their clothing differed from that of the Mayas, and that the Cuban natives with him could not understand the Maya language. *Historia Verdadera*, cap. II.

Physically they were undersized, less muscular than the Spaniards, light in color, with thick hair and scanty beards. Their foreheads were naturally low and retreating, and they artificially flattened the skull by pressure on the forehead or the occiput.[34]

Three social grades seem to have prevailed, the common herd, the petty chiefs who ruled villages, and the independent chiefs who governed provinces. Of the latter there were in Cuba twenty-nine; in Haiti five, as near as can be now ascertained.[35] Some of those in Cuba had shortly before the arrival of the Spaniards moved there from Haiti, and at the conquest one of the principal chiefs of Haiti was a native of the Lucayos.[36]

The fate of these Indians is something terrible to contemplate. At the discovery there were probably 150,000 on Cuba, Haiti, and the Bahamas.[37] Those on the latter were carried as slaves to Haiti to work in the mines, and all of the Lucayos exterminated in three or four years (1508–1512).[38] The sufferings of the Haitians have been told in a graphic manner by Las Casas in an oft-quoted work.[39] His statements have frequently been condemned as grossly exaggerated, but the official documents of the early history of Cuba prove but too conclusively that the worthy missionary reports correctly what terrible cruelties the Spaniards committed. Cuba was conquered in 1514, and was then quite densely populated. Fourteen years afterwards we find the Governor, Gonzalo de Guzman, complaining that while troops of hunters were formerly traversing the island constantly, asking no other pay than the right of keeping as slaves the natives whom they captured, he now has to pay patrolmen, as the Indians are so scarce.[40] The next year (1529) the treasurer, Lope de Hurtado, writes that the Indians are in such despair that they are hanging themselves twenty and thirty at a time.[41] In 1539 the king is petitioned to relinquish his royalty on the produce of the mines, because nearly all the Indians on the island are dead.[42] And in 1532 the licentiate, Vadillo, estimates the total number of Indians on the island, including the large percentage brought from the mainland by the slavers, at only 4,500.[43]

As a specimen of what the treatment of the Indians was, we have an accusation in 1522 against Vasco Porcallo, afterwards one of the companions of Hernando de Soto. He captured several Indians, cut off their genitals, and forced them to eat them, cramming them down their throats when they could not swallow. When asked for his defence, Porcallo replied that he did it to prevent his own Indians from committing suicide, as he had already lost two-thirds of his slaves in that way. The defence was apparently deemed valid, for he was released![44]

The myths and traditions of the Haitians have fortunately been preserved, though not in so perfect a form as might be wished. When Bartholomew Columbus left Rome for the Indies, he took with him a lay brother of the order of the Hermits of St. Jerome, Ramon Pane by name, a Catalan by birth, a worthy but credulous and ignorant

[34] "Presso capite, fronte lata" (Nicolaus Syllacius, *De Insulis nuper Inventis*, p. 86. Reprint, New York, 1859. This is the extremely rare account of Columbus' second voyage). Six not very perfect skulls were obtained in 1860, by Col. F. S. Heneken, from a cavern 15 miles south-west from Porto Plata. They are all more or less distorted in a discoidal manner, one by pressure over the frontal sinus, reducing the calvaria to a disk. (J. Barnard Davis, *Thesaurus Craniorum*, p. 236, London, 1867. Mr. Davis erroneously calls them Carib skulls).

[35] The provinces of Cuba are laid down on the *Mapa de la Isla de Cuba segun la division de los Naturales*, por D. Jose Maria de la Torre y de la Torre, in the *Memorias de la Sociedad Patriotica de la Habana*, 1841. See also Felipe Poey, *Geografia de la Isla de Cuba*, Habana, 1853. *Apendice sobre la Geografia Antigua.* Las Casas gives the five provinces of Hayti by the names of their chiefs, Guarinox, Guacanagari, Behechio, Caonabo and Higuey. For their relative position see the map in Charlevoix's *Histoire de l'Isle San Domingue*, Paris, 1740, and in Baumgarten's *Geschichte von Amerika*, B. II.

[36] This was Caonabo. Oviedo, and following him Charlevoix, say he was a Carib, but Las Casas, who having lived twenty years in Haiti immediately after the discovery, is infinitely the best authority, says: "Era de nacion Lucayo, natural de las islas de los Lucayos, que se pasó de ellas aca." (*Historia Apologetica*, cap. 179, MSS).

[37] I put the figures very low. Peter Martyr, whose estimates are the lowest of any writer, says there were more than 200,000 natives on Haiti alone. (*De Rebus Oceanicis*, p. 295.)

[38] More than 40,000 were brought to Haiti to enjoy the benefits of Christian instruction, says Herrera, with what might pass as a ghastly sarcasm. (*Historia General de las Indias*, Dec. I, lib. VIII, cap. 3).

[39] *Brevissima Relacion de la Destruccion de las Indias Occidentales por los Castellanos*, Sevilla, 1552.

[40] Ramon de de la Sagra, *Historia de la Isla de Cuba*, Tom. II, p. 381.

[41] Ibid, p. 394.

[42] Ibid, p. 396.

[43] Ibid, p. 414.

[44] Ibid, p. 385. These references to De la Sagra's work are all to the original documents in his Appendix.

man.[45] On reaching Haiti brother Pane was first sent among the natives of the small province called Macorix de abajo, which had a language peculiar to itself, but he was subsequently transferred to the province of Guarinoex on the southeastern part of the island where the *lengua universal* prevailed. He remained there two years, and at the request of Columbus collected and wrote down the legends and beliefs of the natives.

He is not a model authority. In the first place, being a Catalan he did not write Spanish correctly; he was very imperfectly acquainted with the native tongue; he wrote hastily, and had not enough paper to write in full; he is not sure that he commences their legends at the right end. Moreover his manuscript is lost, and the only means we have of knowing anything about it is by a very incorrectly printed Italian version, printed in 1571, and two early synopses, one in Latin in the Decades of Peter Martyr, the other in Italian, by Messer Zuane de Strozi of Ferrara, which has been quite recently published for the first time.[46] By comparing these we can arrive at the meaning of Brother Pane with considerable accuracy.

His work contains fragments of two distinct cycles of legends, the one describing the history of the gods, the other the history of the human race.

Earliest of creatures was the woman, A'abéira or Ataves, who also bore the other names Mamóna, Guacarapíta, Iiélla, and Guimazóa. Her son was the supreme ruler of all things, and chiefest of divinities. His names were Yocaúna, Guamaónocon, and Yocahu-vaguaniao-vocoti. He had a brother called Guaca, and a son Iaiael. The latter rebelled against his father, and was exiled for four months and then killed. The legend goes on to relate that his bones were placed in a calabash and hung up in his father's house. Here they changed into fishes, and the calabash filled with water. One day four brothers passed that way, who had all been born at one time, and whose mother, Itaba tahuana, had died in bringing them into the world. Seeing the calabash filled with fish the oldest of the four, Caracaracol, the Scabby, lifted it down, and all commenced to eat. While thus occupied, Yocaúna suddenly made his appearance, which so terrified the brothers that they dropped the gourd and broke it into pieces. From it ran all the waters of the world, and formed the oceans, lakes, and rivers as they now are.

At this time there were men but no women, and the men did not dare to venture into the sunlight. Once, as they were out in the rain, they perceived four creatures, swift as eagles and slippery as eels. The men called to their aid Caracaracol and his brothers, who caught these creatures and transformed them into women. In time, these became the mothers of mankind.

The earliest natives of Haiti came under the leadership of the hero-god, Vaguoniona, a name applied by Las Casas to Yocahu, from an island to the south called in the legend Matininó, which all the authors identify, I know not why, with Martinique. They landed first on the banks of the river Bahoboni in the western part of Haiti, and there erected the first house, called Camotéia. This was ever after preserved and regarded with respectful veneration.

Such, in brief, were their national myths. Conspicuously marked in them we note the sacred number four, the four brothers typifying the cardinal points, whose mother, the Dawn, dies in giving them birth, just as in the Algonkin myths. These brothers aid the men in their struggles for life, and bring to them the four women, the rain-bringing winds. Here, too, the first of existences is the woman, whose son is at once highest of divinities and the guide and instructor of their nation. These peculiarities I have elsewhere shown to be general throughout the religions of America.[47]

The myth of the thunder storm also appears among them in its triplicate nature so common to the American mind. God of the storm was Guabancex, whose statue was made of stones. When angry he sent before him as messenger, Guatauva, to gather the winds, and accompanied by Coatrischie, who collected the rain-clouds in the valleys of the mountains, he swept down upon the plain, surrounded by the awful paraphernalia of the thunder storm.[48]

[45] Las Casas knew Pane personally, and gives his name correctly (not *Roman*, as all the printed authorities have it). He described him as "hombre simple y de buena intencion;" "fuese Catalan de nacion y no habla del todo bien nuestra lengua Castellana." Ramon came to Haiti four or five years before Las Casas, and the latter speaks of him in a disparaging tone. "Este Fray Ramon escudrino lo que pudó, segun lo que alcanzo de las lenguas que fueron tres, las que habia en esta ysla: pero no supo sino la una de una chica provincia, que arriba dejimos llamarse Macaria de abajo, y aquella no perfectamente. (*Historia Apologetica, MSS.* cap. 120, see also cap. 162). This statement is not quite true, as according to Las Casas' own admission Pane dwelt two years in the province of Guarinoex, where the *lengua universal* was spoken, and *there* collected these traditions.

[46] Pane's account was first published in the *Historie del Frenando Colombo*, Venetia, 1571, from which it has recently been translated and published with notes by Brasseur de Bourbourg, Paris, 1864. The version of Zuane de Strozi is in the Appendix to Harrisse's *Bibliotheca Primordia Americana*, p. 474.

[47] *The myths of the New World*, (New York, 1868).

[48] See the work last quoted, p. 156, for a number of similar myths of the trinity of the storm.

Let us place side by side with these ancient myths the national legend of the Arawacks.[49] They tell of a supreme spiritual being Yauwahu or Yauhahu. Pain and sickness are the invisible shafts he shoots at men, *yauhahu simaira* the arrows of Yauhahu, and he it is whom the priests invoke in their incantations. Once upon a time, men lived without any means to propitiate this unseen divinity; they knew not how to ward off his anger or conciliate him. At that time the Arawacks did not live in Guiana, but in an island to the north. One day a man named Arawanili walked by the waters grieving over the ignorance and suffering of his nation. Suddenly the spirit of the waters, the woman Orehu, rose from the waves and addressed him. She taught him the mysteries of *semeci*, the sorcery which pleases and controls Yauhahu, and presented him with the *maraka*, the holy calabash containing white pebbles which they rattle during their exorcisms, and the sound of which summons the beings of the unseen world. Arawanili faithfully instructed his people in all that Orehu had said, and thus rescued them from their wretchedness. When after a life of wisdom and good deeds the hour of his departure came, he "did not die, but went up."

Orehu accompanied the Arawacks when they moved to the main, and still dwells in a treeless, desolate spot, on the banks of the Pomeroon. The negroes of the colony have learned of her, and call her in their broken English, the "watra-mamma," the water-mother.

The proper names which occur in these myths, date back to the earliest existence of the Arawacks as an independent tribe, and are not readily analyzed by the language as it now exists. The Haitian Yocauna seems indeed identical with the modern Yauhahu. Atabes or Atabéira is probably from *itabo*, lake, lagoon, and *era*, water, (the latter only in composition, as *hurruru*, mountain, *era*, water, mountain-water, a spring, a source), and in some of her actions corresponds with Orehu. Caracaracol is translated by Brother Pane, as "the Scabby" or the one having ulcers, and in this respect the myth presents a curious analogy with many others in America. In modern Arawack *karrikala* is a form, in the third person singular, from *karrin*, to be sick, to be pregnant. Arawanili, which one might be tempted to suppose gave the name Arawack to the tribe, did not all writers derive this differently, may be a form of *awawa*, father. In the old language, the termination *el*, is said to have meant son.

Of the two remaining languages said to have been spoken in the small provinces of Macorix de arriba and Macorix de abajo, in Hayti, we have no certain knowledge.[50] Las Casas gives one word from the former. It is *bazca*, no, not. I cannot identify it. There is reason, however, to suppose one of them was the Tupi or "lengua geral," of Brazil. Pane gives at least two words which are pure Tupi, and not Arawack. They are the names of two hideous idols supposed to be inimical to men. The one was Bugi, in Tupi, *ugly*, the other Aiba, in Tupi, *bad*. It is noteworthy, also, that Pigafetta, who accompanied Magellan on his voyage around the world, gives a number of words, ostensibly in the language of the natives of Rio Janeiro, where the Tupi was spoken, which are identical with those of Haiti, as *cacich*, chief, *boi*, house, *hamac*, bed, *canoe*, boat. But Pigafetta acknowledges that he obtained these words not from the natives themselves, but from the pilot Juan Carvalhos, who had been for years sailing over the West Indian seas, and had no doubt learned these words in the Antilles.[51]

The remaining idiom may be supposed to have been Carib, although we have actually no evidence that the Caribs had gained a permanent foothold on any of the Great Antilles at the period of the discovery, some careless assertions of the old authors to the contrary, notwithstanding.

The investigation which I here close, shows that man in his migrations on the Western Continent followed the lead of organic nature around him. For it is well known that the flora and fauna of the Antilles are South American in character, and also, that the geological structure of the archipelago connects it with the southern mainland. So also its earliest known human inhabitants were descended from an ancestry whose homes were in the far south, and who by slow degrees moved from river to river, island to island, until they came within a few miles of the northern continent.

[49] I take these as they are related in Bretts, *Indian Tribes of Guiana*, Part ii, chap. x.

[50] The most trustworthy author is Las Casas. As his works are still in manuscript, I give his words. "Tres lenguas habla en esta ysla distintas que la una a la otra no se entendia. La una era de la gente que llamabamos Macorix de abajo y la otra de los vecinos del Macorix de arriba. La otra lengua fue la universal de toda la tierra, y esta era mas elegante y mas copiosa de vocablos, y mas dulce al sonido. En esto la de Xaragua en todo llevaba ventaja, y era mui mas prima." (*Historia Apologetica*, cap. 197). "Es aqui de saber que un gran pedajo de esta costa (that of the northern part of Haiti), bien mas de veinte y cinco o treinta leguas y quince buenas y aun veinte de ancho hasta las sierras que haren desta parte del norte la gran Vega inclusive, era poblado de una gente que se llamaron Mazoriges, y otras Ciguayos, y tenian diversas lenguas de la universal de todas las islas." (*Historia General*, lib. I, cap. 77). "Llamaban Ciguayos porque trayan todos los cabellos mui luengos como en Nueva Castilla las mujeres," (id. cap. 77). The cacique of the Ciguayos was named Mayomanex or Mayobanex, (id. lib. I, cap. 120). They went almost naked, and had no arms, "eran Gallinas almenos para con los uños, como no tuviesen armas," (id. cap. 120.)

[51] Pigafetta, *Reise um die Welt*, ss. 21, 26, 247, (Gotha, 1802; a translation of the Italian original in the library at Milan).

CONTRIBUTION TO THE ICHTHYOLOGY OF THE LESSER ANTILLES.

By Edward D. Cope, A. M.

(*Read before the American Philosophical Society, October* 7, 1870.)

The present synopsis has been prepared from the following materials. A large collection in alcohol made at the Island of St. Martin's, by Dr. R. E. van Rijgersma, of that place. A considerable collection made at St. Croix or Santa Cruz, by Dr. R. E. Griffith, of this city, the specimens mostly dried and mounted. A second collection made at the same island by Capt. Thos. Davidson of the navy, in alcohol. A collection embracing many specimens of large size, made at St. Christopher's or Kit's by our fellow citizen Benjamin H. Lightfoot. The thanks of American ichthyologists are due to these gentlemen for the liberal manner in which they have devoted themselves to the interests of this science.

An identification of the species obtained by our member, Dr. H. C. Wood, at New Providence, has been inserted, as furnishing important evidence as to the nature of the ichthyic fauna of a point so much nearer the American coast.

In general, the full determination of the fish-fauna of the North Eastern region of the Lesser Antilles, will prove of much interest to science, as furnishing a point intermediate between the ground studied so well by Professor Poey, of Havana, and the island of Barbadoes, which has furnished the collections studied by Müller and Troschel. To this end we look with confidence to Dr. Rijgersma whose interest in the various natural sciences has already produced important results in different departments. See on the Fossil Mammalia and Reptilia of Anguilla and St. Martin's, these Proceedings of this Society, 1869, pp. 183—159.

In determining these species of fishes, I have of course used chiefly the standard works of Cuvier and Valenciennes and of Günther; the latter, as bringing the history of the species of fishes more nearly up to the time, is the more important of the two. I have found the published researches of Poey on the fishes of Cuba a *sine qua non*, and the essays of Gill have furnished many important points in the higher department of the system. The Plectognath monographs of Hollard, and the writing of Bleeker on that type and the Apodes, cannot be done without in this field.

The engravings are specimens of the Bien photometallic process, and are printed with the text. They illustrate the results of photography of drawings, on metallic plates.

I. OBSERVATIONS ON THE SYSTEMATIC RELATIONS OF THE FISHES.

I. Preliminary.

The system of fishes as at present adopted in this country is the result of the labors of many naturalists, but chiefly of Cuvier, Agassiz, Müller, and Gill. Without going into the history of the subject at present, it will be proper to point out the principal modifications of Cuvier's system introduced by his three successors. The orders of Cuvier, were the *Chondropterygii, Malacopterygii, Acanthopterygii, Plectognathi,* and *Lophobranchii.* Professor Agassiz under the name of *Placoides,* adopted the first division, the second he called the *Cycloids,* the third *Ctenoids,* and then erected a fourth order under the name of *Ganoids,* which should embrace a portion of Cuvier's *Chondropterygii* (the sturgeons), a portion of the *Malacopterygii Abdominales* (the bony gars, etc.), and the two last orders of Cuvier. Professor Müller following, with a still more complete anatomical investigation, especially into the soft parts, discerned three *sub-classes* in Cuvier's *Chondrostomi,* which he named the *Leptocardi* (lanclet), *Dermopteri* (lamprey, etc.), and the *Selachii* (Sharks, etc). In the then recently discovered Lepidosiren he saw on fourth sub-class, the *Dipnoi.* Having instituted an investigation of Agassiz' Ganoids, in an able memoir he purged it of the *Plectognath* and *Lophobranchiate* divisions, which are obviously not related to it. These, with the *Malacopterygians* and *Acanthopterygians,* he erected into a sixth sub-class, the *Teleostei.* This sub-class containing the greater part of existing fishes, embraced six orders, viz.: *Acanthopteri* (Cuvier's Acanthoptergians), *Anacanthini* (new, for the Cod family, etc.), *Pharyngognathi* (new,

for fishes with connate inferior pharyngeal bones), *Physostomi* (Malacopterygians of Cuvier, nearly), *Plectognathi* and *Lophobranchii* of Cuvier. The great number of facts in the anatomy of fishes added by Müller, constitute him the father of modern ichthyology.

Prof. Gill, in 1861, adopted many of the divisions of Müller, and rejected some; others were newly proposed. But four sub-classes were recognized, the *Dermopteri* which included also Müller's Leptocardii, the *Elasmobranchii*, equivalent to Müller's Selachii; the *Ganoidei*, including here Müller's Dipnoi, and the *Teleostei*. Six orders were attributed to the last sub-class, which were quite different from those of Müller. Thus adopting the *Plectognathi* and *Lophobranchii*, the cat fishes were erected into a new order, the *Nematognathi;* the eels into another, *Apodes*, and the ribbon-fishes doubtfully assigned to another, called *Lemniscati*. The remainder of the bony fishes were regarded as constituting the sixth and highest, or *Teleocephali*. To this as sub-orders were referred, the old orders *Physoclysti* (Acanthopteri Pharyngognathi and Anacanthini of Müller), and *Physostomi* of Müller; with the new ones *Heterosomata* (the flat fishes), and *Eccntognathi* (the Cyprinidæ).

Subsequent to this publication, important contributions to the system have been made by Agassiz, Kner, Lütken, Gill, Huxley, etc., which will be noticed at the proper time.

The writer having been engaged in an examination of the osteology of the bony fishes, and general anatomical structures of the whole, has proposed to point out some further modifications of the received system, which he believes will render it a closer reflection of nature. There are some portions of the skeleton which have been to a great extent overlooked in seeking for indications of likeness and difference of types, and the estimation in which many known characters are held, may be much altered on the study of extended material. The skeletons on which the present study is made are 1000 in number, 200 belonging to the Academy of Natural Sciences, of this city, and 800 to the writer, being the collection made by Professor Joseph Hyrtl, the distinguished anatomist of Vienna. This collection has been long known to anatomists in Europe as the most beautifully and reliably prepared in existence, and as valuable as any, for study, on account of the fulness of the representation of the various types.

2. Special on the Ganoids.

Recurring to Müller's system, the writer adopts, as characterized beyond dispute, his sub-classes or orders of Leptocardii, Dermopteri, Selachii and Dipnoi, and confines himself at present to the recent *Ganoidea* and *Teleostei*. I have shared in the doubts occasionally expressed by ichthyologists, as to the essential distinction of these latter divisions, and an examination into the osteology, with reference to this point, confirms the doubts raised by a study of the soft parts. As is well known, Müller distinguished the Ganoidea by the muscular bulbous arteriosus containing numerous valves, and the connection of the optic nerves by commissure rather than by decussation. He added several other characters, knowing them, however, to be shared by various other orders and subclasses, and I have selected the only two which seemed to be restricted to the division. Their restriction to it, however, is only apparent, and Kner points out that the peculiarity of the optic commissure is shared by some *Physostomi*, and that the difference between the number and character of the valves of the bulbus in *Lepidosteus* and *Amia* is quite as great as that existing between *Amia** and some of the *Physostomi*. After an examination of the skeleton, it is obvious that, in this part of the organism also, there is nothing to distinguish these fishes from the *Teleostei* of Müller. It is true that each of the genera referred to it possesses marked skeletal peculiarities, but they are either not common to all of them, or are shared by some of the *Physostomi*. If, on the other hand, we compare these genera with each other, differences of the greatest importance are observable, which at once distinguish two divisions, one represented by *Polypterus*, the other by *Lepidosteus* and *Amia*.

In the first place, the basal radii of the pectoral fins of *Polypterus* are observed to be excluded from articulation with the scapular arch by the intervention of three elements, which form a pedicel or veritable arm for the fin; in *Lepidosteus* and *Amia* the radii are sessile on the scapular arch as in ordinary fishes. The ventral fins present a like difference; the basal radii are long, and four in number in *Polypterus*. In the other two genera they are absent, excepting one rudimental ossicle on the inner basis of the fin (two in *Lepidosteus*), precisely as in the Physostomous families *Mormyridæ*, *Catostomidæ*, etc. If we examine the branchial apparatus, we find an undivided ceratohyal, three branchihyal arches, and no inner and but two outer bones of the superior branchihyals present in

* See Franque Nonnul. ad Amiam calvam, Tab. 1, fig. 10.

Polypterus. In *Lepidosteus* and *Amia*, we have the double ceratohyal, four branchihyal arches with four outer and four inner superior elements, all characters of the typical *Teleostei*. The maxillary bone of *Polypterus* instead of being free distally as in fishes generally, is united with an ectopterygoid, and with bones representing, in position at least, postorbital and malar. In the other genera, the relations of the maxillary are as in osseous fishes.

The sturgeons, *Accipenseridæ*, agree with *Amia*, etc., in all of these points but one, differing only in having the superior ceratohyal and several of the superior branchihyals cartilaginous. The one point of distinction is, the extension of the basal radial supports of the ventral fin all across its basis, as in *Polypterus*. The pectoral fin is, on the other hand, much as in *Lepidosteus*. Thus the sturgeons combine, in this one respect, the features of both divisions. Both the basal ceratohyals are cartilaginous in this family; the superior only is cartilaginous in *Polypterus*, *Lepidosteus* and *Amia*, while both are ossified in the old *Teleostei*, except in the eels. In these, the inferior is cartilaginous, while the superior is coössified to the ceratohyal. Thus in one unimportant character *Polypterus* agrees with its former associates, but differs more from others of them, the sturgeons, than from the bony fishes. Another character of both *Lepidosteus* and *Amia* betoken a certain relationship to *Polypterus*, viz.: the complexity of the mandible, especially in the possession of a coronoid bone. But here, again, *Accipenser* only possesses an osseous dentary, while *Gymnarchus* and *Gymnotus* have the angular and articular bones distinct from the dentary, wanting the coronoid and opercular. In most bony fishes the angular is not distinct.

It is thus evident that the sub-class Ganoidea, cannot be maintained. It cannot even be regarded as an order, since I will show that *Lepidosteus*, *Accipenser* and *Amia*, are all representatives of distinct orders. I hope also to make it evident that *Polypterus* should be elevated to the rank of a sub-class or division of equal rank with the rest of the fishes, and with the *Dipnoi* already adopted.

3. Relations to other Vertebrata.

The primary divisions of the vertebrata as expressed by the skeleton, have been defined by Huxley in a very satisfactory manner, up to a certain point. Thus the Mammalia are distinguished by the reception of the proximal bones of the mandibular arch into the auditory capsule, as *ossicula auditus*, and by the absence of distinct coracoid bone. The ear-bones support the under jaw in the groups that follow, and a separate coracoid bone exists. The division of birds and reptiles together, or Sauropsida, possesses limbs with but few and special radii, an osseous basis cranii, without parasphenoid bone, and one aorta root or two of one bow on each side (rarely a second bow). The division next below, or Batrachia, was shown to possess no osseous basis cranii, whose place is taken by the membrane bows, the parasphenoid: limbs with but few radii, and an aorta originating from two roots, attached to which are three or four bones on each side.

Following these, is the great group of fishes, in which the limbs are many rayed or jointed, or fins; a parasphenoid present, and pelvis generally wanting. The stapes, which has not in the preceding groups shared in the support of the mandible, is now projected from the brain case so as to share with the malleus (quadrate) in this support, being still the proximal element in the hyoid arch, as in the preceding classes. There are five (rarely four) aorta bows which unite to form the aorta root on each side. The cranium is cartilaginous or osseous, and the mandibular arch present. Below these come the Demopteri, where the limbs are wanting, and the mandibular arch absent: the cranium cartilaginous. In the lowest group or Leptocardii, there is no differentiated brain, the cranium is membranous and without arches: limbs wanting, and five aorta bows as in the last division.

These six classes of vertebrata appear to be well established. The question remains as to whether naturalists are correct, who regard the fishes as representing variously from two to four classes. One of these (the Ganoidea) having been already disposed of, it remains to consider the claims of the remainder, viz.: the Elasmobranchii (sharks) Dipnoi and typical fishes.

If we examine the points in which the whole, taken together, differs from the *Batrachia* and other classes above it, we find that it is confined chiefly to the structure of the limbs and the hyoid apparatus. The typical fishes present, however, other important peculiarities, viz.: 1st. The existence of two or three distinct bones in the suspensor of the mandible, instead of one; 2d. The attachment to these of the opercular bones; 3d. The absence of pelvic bones; 4th. The suspension of the scapular arch to the cranium; 5th. The large development of the pterotic (Parker, *Mastoid*, Cuvier, and Owen) is characteristic of bony fishes.

The types of variation in the first point, only distinguish groups of subordinate rank. Thus the suspensor of the mandible in the typical fishes consists of the hyomandibular (stapes), quadrate (metapterygoid or incus), symplectic and mesopterygoid (quadratojugal Müller, quadrate Huxley, Elem. Comp. Anat.). In the *Mormyridæ*, *Siluridæ*, *Polypteridæ* (scap. arch), and others, the symplectic is absent; in the eels of several families, both it and the metapterygoid are wanting, reducing the suspensorium to a rod of two pieces. This condition exists in many of of the rays; in others, and in the sharks, the inferior element is wanting (Müller Stannius). An important modification is exhibited by *Chimæra*, where the hyomandibular, which alone exists, is continuous with the cartilaginous cranium, not being separated by the usual articulation. As to the opercular bones, all are wanting in the Elasmobranchs (sharks and rays), while the typical fishes possess four, viz.: preoperculum, operculum, suboperculum, and interoperculum. In many of these, however, the suboperculum is wanting, and in the sturgeons and many eels there is no preoperculum. In *Polyodon* the interoperculum is also wanting. In *Lepidosiren* the operculum and interoperculum are rudimental. In respect to this point, also, the divisions indicated are of subordinate value. As regards the development of the pterotic bone, its history is not yet sufficiently made out to enable us to understand its value. It does not exist in those with cartilaginous cranium (*Elasmobranchii*). The Elasmobranchs are well known to have the scapular arch suspended freely behind the cranium as in higher vertebrates. It is not always attached to the cranium, on the other hand, among true fishes, for in the eels it is quite as in the sharks, and the spinous finned Mastacembelus presents the same feature.

The character presented by the pelvic bones and limbs seem to be of higher import. Thus all the bony fishes and sturgeons lack all the pelvic elements. In the sharks and rays they are also wanting, but two elements on each side appear in the *Holocephali* (*Chimæra*), according to Leydig and Gegenbaur. In *Lepidosiren*, a large median pelvic cartilage exists, but which element it represents is unknown. This is evidently a character of high significance. As to the limbs, the peculiarities of *Polypterus* have been pointed out above. They mean nothing less than the development of the elements of the arm and leg of the higher Vertebrata, which intervene between the point of articulation and the distal segments, in Polypterus and the sharks and rays. In the former, the distal segments are articulated exclusively to the extremities of the proximal pieces, which thus resemble, as well as represent, humerus and femur, and render the limb pedunculated. The proximal pieces are not continued distally, however, into the representatives of the main axis, which, as demonstrated by the admirable studies of Gegenbaur, consist, after humerus, of radius, inner tarsals and metatarsals, and thumb; in the hind limb, of the line of the tibia and inner toe. This continuation is observed in the Elasmobranchs, where, however, the divergent segments extend along the sides of the proximal pieces to near, in some *Rajidæ* quite, to the articulation with the scapular arch. In the true fishes, including some of the old ganoids already considered, the divergent rays always reach this articulation, while the number of proximal or basal pieces is diminished. These pieces have been called by Gegenbaur the Metapterygium (humerus), Mesopterygium, and Propterygium; the first being axial, the second and third being divergent from it. In Polypterus, the Propterygium and Mesopterygium are largely developed; in sharks and rays the propterygium is sometimes small, sometimes wanting, while in the true fishes the propterygium and mesopterygium are both wanting, except in Amia, Lepidosteus, and the sturgeons, where a cartilaginous mesopterygium exists, according to Gegenbaur. This author finds it rudimental in young *Salmonidæ* and *Siluridæ*. Lastly, in the true fishes the distal elements of the axis of the limb are wanting just as in *Polypterus*.

In Dipnoi, on the other hand, we have this axis complete, or rather with greatly multiplied distal segments, and with uni- or bilateral radii. The bilateral type is seen in *Ceratodus* and the acute-lobed *Crossopterygia*, according to Günther. Hence the limb in this order is termed by Owen, the simplest or primary type, and this proposition is abundantly confirmed by the beautiful researches of Gegenbaur. The foundation for the history of the genesis of limbs laid by this author, will ever be a land-mark in the history of modern theories of creation.*

Important as are the characters that distinguish the several groups indicated by the different types of structure of the limbs and pelvis, they do not seem to me to warrant their recognition as classes, equivalent to those of the six already pointed out. Taking them together, there is a greater coherence also in the structure of the brain and circulatory systems than is held to be the case with any other two of the classes adopted above. The peculiarities of the limbs, important as they are, are quite similar in the want of the high specialization of their parts seen in the

*See his memoir Ueber das Skelet der Gliedmaasen der Wirbelthiere im Allgemeinen etc. Jenaische Med. Zeitschr. Vol. V. p. 397.

Batrachia and higher classes, the differences consisting rather of number and position of parts. The pelvis of the *Dipnoi* might be regarded as of primary importance but for its existence in the *Holocephali*, whose limbs again are so near those of the sharks. It remains, therefore, to adopt the Linnaean and Cuvierian class PISCES, and to grant as sub-classes the groups of *Holocephali*, *Selachii* and *Dipnoi*. There remain as sub-classes the groups typified by *Polypterus* on the one hand, and the true fishes on the other. The first has been already distinguished in its external characters by Prof. Huxley, who again brought light out of obscurity when he established "his third sub-order of Ganoids, the *Crossopterygidæ*."* This division is in my estimation a natural one, and to be elevated to a rank equivalent to that of each of the three aboved named, being the only part of the original division of Ganoids of Agassiz entitled to it. Prof. Huxley defined it as follows: "Dorsal fins two, or if single, multifid or very long; the pectoral and usually the ventral fins lobate; no branchiostegal rays, but two principal with sometimes lateral and median jugular plates situated between the rami of the mandibles; caudal fin diphycercal or heterocercal; scales cycloid or rhomboid, smooth or sculptured."

Of the above characters, that which relates to the lobate fins is the essential one, and is the expression of the external appearance produced by the structure of the bones of the limbs already pointed out by Gegenbaur. The dorsal fins of some families it is true, possess a remarkable structure, but in *Phaneropleuron*, Huxl. and some others, appears to be nearly like that of the *Dipnoi*. The absence of branchiostegal rays is important, but is shared by the sturgeons. The jugular plates appear to exist in *Polypterus* only among recent fishes, though several, as *Amia*, *Elops*, *Osteoglossum*, etc., possess a median one. Nevertheless, its nature would not lead one to anticipate its being a constant feature in any group of high rank; at least such is our usual experience with dermal bones. The structures of the skin and scales given by Huxley are very subordinate.

The remaining division answers then to the Teleostei and Ganoidea of Müller, minus *Polypterus*. The name Teleostei cannot be preserved for this division owing to its entire want of coincidence with that division of Müller, as well as from the fact that the cartilaginous sturgeons must be included in it. I propose, therefore to call it the *Actinopteri*.† The characters of the five sub-classes will then be as follows:

Class PISCES.

The hyomandibular bone continuous with the cartilaginous cranium, with a rudimental opercular bone. Two distinct pelvic bones on each side. Derivative radii sessile on the sides of the basal bones of the limbs, separated from the articulation. HOLOCEPHALI.

Hyomandibular bone articulated with the cranium; no opercular pelvic bones. Derivative radii sessile on the sides of the basal bones of the limbs, rarely entering articulation. SELACHII.

Hyomandibular bone articulated; rudimental opercular bones. A median pelvic element. Limbs consisting of the axial line commencing with the metapterygium and with multiplied axial and often lateral segments. DIPNOI.

Hyomandibular articulated, opercular bones well developed, a single ceratohyal; no pelvic elements. Limbs having derivative radii of the primary series on the extremity of the basal pieces, which are in the pectoral, metapterygium, mesoptergium, and propterygium. CROSSOPTERYGIA.‡

Opercular bones well developed on separate and complex suspensorium; a double ceratohyal, no pelvic elements. Primary radii of fore limb parallel with basilar elements, and entering the articulation with scapular arch. Basilar elements reduced to metapterygium and very rarely mesopterygium. Primary radii of posterior limb generally reduced to one rudiment. ACTINOPTERI.

The only sub-classes considered here are the last two.

*See Mem. Geolog. Survey United Kingdom Decade x. p. 23.

† From $\alpha\kappa\tau\iota\varsigma$ a radius, and $\pi\tau\epsilon\rho o\nu$ fin or wing, from the support of the fins by the radial elements only.

‡ Altered from Huxley's *Crossopterygidæ*.

4. On the Crossopterygia.

My object in alluding to the present subclass is to point out the ordinal characters of *Polypterus* as compared with others of the same primary division, and of the *Actinopteri*. The elucidation of this point depends first on the explanation of the structure of the dorsal fin. This is one of the most extraordinary peculiarities of the genus in question, and has never been brought into harmony with that exhibited by other divisions of fishes so far as I am aware. The dorsal fin of *Polypterus* consists of a number of independent pinnules. Each of these consists of a strong spinous ray supported by a single interneural bone. From the posterior face of the ray projects a number of soft or cartilaginous rays, obliquely backwards, forming a vertical series. Thus results a series of vertical dorsal fins standing on end instead of horizontally as in other fishes. The significance of this structure appears to be as follows:

In the *Dipnoi*, we observe the archetypal fin almost realized. Each neural spine bears an interneural bone, and each interneural a basal radial bone. Beyond these are the numerous distal or cartilaginous radii, which greatly exceed in number the interneural bones. In the Dipnoan *Phaneropleuron*, according to Prof. Huxley's figure and description, each interneural supports a basal radial, and this in its turn a number of true radii. In the caudal fin of *Polypterus* as we pass towards the dorsals we find the transition from the rays with jointed, forked extremity continuous with the base, to the dorsal pinnules, to be complete.* The basal portion of the ray loses its jointed character, and more in front than posteriorly; the anterior surface becomes sculptured like the spines that support the pinnules, and the sides begin to project in an angle which, in the next spine, becomes a free margin. The apex, separating at the first joint from its terminal, jointed portion, the latter appears to issue from a fissure in its apex. In the next spine, this fissure is prolonged downwards on the posterior face, and the jointed divisions are more widely separated. Their number also is increased in each by the continuation of a fissure which divided the upper ray of the last pinnule above described, for about half its length to the base. In the anterior pinnule the inferior, now horizontal, ray is considerably nearer the base of the spine than in those nearer the tail.

The preceding succession displayed by the pinnules from behind forwards is no doubt a developmental one, representing truly the origin of the more specialized, since the rays of the tail are unquestionably in the primitive condition already stated to characterize the dorsal fin of *Phaneropleuron*. It has also a complete analogy to the succession which we trace in the types of the pectoral fin, commencing with the simple axis of the *Dipnoi*, and passing to the axis with lateral appendages or radii, seen in *Selache* (Gegenbaur l. c.) and that traced below in the caudal.

Carrying the process on, in the line already commenced, if we bring the radii to the plane of the basis of the basal ray or spine, we have the number of rays in the basal radial band greatly increased. Should they ossify, as we have seen them to do in passing from the caudal to the dorsal fins of *Polypterus*, they would be undistinguishable from the basilar rays, just as the primary rays of the pectoral fin in the *Crossopterygia* are undistinguishable from that which was originally the axial. I am not at present acquainted with any genus of this sub-class which presents this character without modification; but if we omit a large number of the interneural spines and their increased basilar rays, all but four in fact, we have exactly the structure presented by the members of the family of the *Cœlacanths*, as figured by Huxley and Egerton, l. c., or the genera *Tristichopterus*, *Cœlacanthus*, *Undina* and *Macropoma*. In several of these the interneural spines are united in pairs, thus supporting two dorsal fins. No doubt others of the order possess this structure, and some intermediate between it and some of the forms already described. We have thus a successional specialization in the structure of the dorsal fin represented by three types, the first being nearest to the *Dipnoi*, the last (*Polypterus* and *Tristichopterus*) being specialized so as to resemble the paired fins, much more so in fact than anything observed in the *Actinopteri*. The three orders may by thus described.

Basal radii equal in number to the interneural spines, with the radii divergent from their extremities. Interneural bones numerous. Haplistia.

Basal radii equal in number to the interneural spines; the distal radii divergent from the posterior margin of the former; interneural bones less numerous. Cladistia fam. *Polypteridæ*.

* This is more obvious in some specimens than others; one from Gondokoro on the upper Nile is most instructive in this respect.

Basal radii much more numerous than the interneural bones radiating from their extremity and continued into branching distal radii; interneurrls much reduced in number. ACTINISTIA, fam. *Coelacanthidæ*.

The basilar segments are entirely wanting in the higher *Actinopteri*, but are variously present in the lower. They are rudimental in the dorsal fin of *Amiurus*, and are more distinct in the dorsal fin of *Gymnarchus* and *Carpiodes*. They are well developed, but short in the dorsal and anal fins of *Coregonus*, *Salmo*, *Elops*, *Mormyrus*, *Osteoglossum*, and even in the spinous rayed *Batrachus*. They are small in the anal fin of *Hydrocyon*. In *Amia* they are long in the anal, but wanting in the dorsal fin. Finally, in the sturgeons they are well marked, but imperfectly ossified in both dorsal and anal fins. In most Clupeidæ and Characinidæ they are not visible, and are wanting in *Heterotis*, *Butyrinus* and *Hyodon*. In all cases where they are present, however, they are greatly more numerous than the vertebræ, as are also the interneural bones.

The origin of this increase suggests itself, and leads back to the proposition discussed with reference to the increase seen in the *Coelacanthidæ*. Should a type of this group be discovered with dorsal fins or pinnules as numerous as those of *Polypterus* and with the structure of those of *Tristichopterus*, we would then be with reference to our increase in the number of interneural bones, nearly where *Polypterus* places us with reference to the increase of the basal segments. We may then suppose that the most divergent of the supernumerary basilars became lateral on the interneural adjacent to each, by the shortening of the axial basilar. That this shortening has taken place, is obvious from the condition in which we find it in the many genera mentioned, and that its effect would be to throw the lateral basilars on to the interneural is almost a necessity. We have thus the high number of interneurals seen in the *Actinopteri* accounted for, and though as yet largely hypothetical, the explanation seems extremely probable.

5. ON THE ACTINOPTERI.

In determining the primary types of this sub-class, we recur to some characters already mentioned, in which they approximate the *Crossopterygia*, and adding others, follow the various divergences to their specialized terminations.

Thus in *Accipenser* and allies the ventral fins possess a complete series of basal radial bones, and the pectorals each a large mesopterygium. In *Amia* and *Lepidosteus*, the mesopterygium is small and the basal radii of the ventrals are reduced to their lowest number. In none of them are the basihyals fully developed. Most of the eels retain a character which we have only observed heretofore in the *Selachii*.

We pass by a number of the lower fishes before we find the mandibular arch furnished with a symplectic. One of the most important modifications, which is more or less coincident with a number of others, is that which formed the basis of Bonaparte and Müller's order of *Physostomi*. The presence of the ductus pneumaticus which characterized it is always associated with an abdominal position of ventral fins and cycloid scales, and mostly with the presence of the præcorocoid arch, the entrance of the maxillary bone into the border of the mouth and the non separation of the parietal bones by the supraoccipital. Yet none of these characters are precisely associated at the point of change in each, for there are Physostomous fishes with separated parietals and ctenoid scales (some *Cyprinodontidæ*) and there are Physoclysti with abdominal ventrals. Nevertheless three prominent types stand out in the *Actinopteri*, the sturgeons or *Chondrostei*, the *Physostomi*, and the *Physoclysti*, and may be considered as tribes.

An entire series of basilar segments of the abdominal ventral fin; no branchiostegal rays.
CHONDROSTEI.

Basilar segments of ventrals rudimental, position of fins abdominal, parietal bones usually united; branchiostegal rays; swim bladder connected with the stomach or œsophagus by a ductus pneumaticus. PHYSOSTOMI.

No ductus pneumaticus; parietal bones separated by the supraoccipital; ventral fins usually thoracic or jugular; no basilar segments. PHYSOCLYSTI.

CHONDROSTEI.

There are two orders in this division, as follows:

A præcoracoid arch; no symplectic bone; premaxillary forming mouth border; no suboperculum nor præoperculum; mesopterigium distinct; basihyals and superior ceratohyal not ossified; interclavicles present. No interoperculum or maxillary bones; branchihyals cartilaginous. 1 SELACHOSTOMI.

Similar to the last, but with interopercle and maxillary bones, and osseous branchihyals.

2 GLANIOSTOMI.

The first order embraces the single family of *Spatularidæ*, the second, that of the *Accipenseridæ*. In both, the chorda dorsalis persists, the tail is heterocercal and the osseous cranium is little developed. The basal and radial elements of the limbs, with the coracoids, are not ossified.

PHYSOSTOMI.

The following key will express the leading features of the orders of this division.

I A præcoracoid arch.

A A coronoid bone.

Maxillary in many pieces; vertebræ opisthocœlian. 3 GINGLYMODI.

Maxillary not transversely divided; vertebræ amphicœlian. 4 HALECOMORPHI.

AA No coronoid bone.

* No symplectic bone.

Pterotic simple, anterior vertebræ with ossicula auditus; supraoccipital and parietals co-ossified.

5 NEMATOGNATHI.

Pterotic annular, including a cavity closed by a special bone; parietals distinct, vertebræ simple.

6 SCYPHOPHORI.

* * Symplectic present.

Anterior vertebræ co-ossified and with ossicula auditus. 7 PLECTOSPONDYLI.

Anterior vertebræ similar distinct, without ossicula auditus; 8 ISOSPONDYLI.

II. No præcoracoid arch.

A Scapular arch suspended to cranium.

* A symplectic.

Pterotic and anterior vertebræ simple; parietals separated by supra-occipital. 9 HAPLOMI.

Anterior vertebræ modified; parietals united; pectoral fins. 10 GLANENCHELI.

* * No symplectic.

Anterior vertebræ simple; a præoperculum and maxillary; no pectoral fins. 11 ICHTHYOCEPHLI.

A A Scapular arch free behind the cranium.

* A preoperculum.

A symplectic; maxillary well developed; no pectoral fins. 12 HOLOSTOMI.

No symplectic; maxillary lost or connate; pectoral fins. 13 ENCHELYCEPHALI.

* * Preoperculum wanting or rudimental.

No symplectic, maxillary, nor pectoral fins; no pterygoid. 14 COLOCEPHALI.

Of the above orders, the *Haplomi* (pike, etc.,) approach nearest the *Physoclysti* of the families *Opheocephalidæ* and *Atherinidæ;* and the *Holostomi* of the family *Symbranchidæ* to the Physoclyst family of *Mastacembelidæ*. The affinities between these families is, in both cases, so close as to render the distinction of the primary divisions in question hardly worth preserving.

The complete development of the support of the caudal fin is seen in many members of this tribe, while in many of them it remains in its primitive condition. Among *Physoclysti* it is nearly always complete, though in a few (*Trichiuridæ*, etc.,) it remains larval.

In the first development of the vertebral column in fishes, it forms a straight axis. The fin is represented by a fold of the integument, which extends equally round its extremity. In this membrane the rays are developed, and in many fishes they remain thus equally distributed. In this case, the caudal vertebræ remain in a straight line to the extremity, and we have a termination such as is seen in *Lepidosiren* and the eels. This form of tail may be called the *isocercal*.

If now, the radii, basal or distal acquire a greater development on the lower side of the end of the column, those

on the upper side remaining rudimental, it will be necessary that such enlarged portion should strike the water in the plane transverse to the longitudinal axis of the body, in order that the weight of the body be propelled with the least expenditure of force. This will necessarily cause the distal vertebræ or end of the chorda dorsalis to be turned upwards, so that the inferior rays of the fin shall be brought as near to the line of the superior as possible. This is the type of tail known as the *heterocercal*, as called by Agassiz.

We find among the *Physoclysti* that the lower rays of the fin are more and more strengthened, and the hæmal spines which support them are more and more enlarged; consequently the end of the column is more curved upwards, as seen in *Amia*. The superior rays and neural spines are also strengthened, and the inferior so extended upwards as to pass round the extremity of the column, and come into contact with them. And now the vertebral centra are successively atrophied from the extremity. Counting from the extremity to the hæmal spines of the first supports of the outer rays of the caudal fin above and below, we find that ten vertebræ remain in the tail of the *Notopterus*. In the *Hyodontidæ Albulidæ*, *Elopidæ*, *Alepocephalidæ* and *Salmonidæ*, there are but two left, while one only appears in the *Osteoglossidæ*, *Aulopidæ*, *Lutodiridæ*, *Butyrinidæ*, *Coregonidæ*, *Clupeidæ* and *Chirocentridæ*. In most other families, especially of *Physoclysti*, the last one has disappeared, and the numerous hæmal arches are arranged like radii diverging upwards and downwards from the last caudal vertebræ. In the highest groups, as *Pharygognathi*, etc., they become coössified, and the tail has completed its specialization. This is the type called homocercal by Agassiz, and diphycercal by later writers.

These types are thus plainly stages in the development of this member, the first and second being simply of development of the last. Thus the young Salmon commences with an eel-like vertebral column, or is *isocercal*; it presently, by the upward curvature of the column, and unequal development of the caudal fin becomes *heterocercal*. Aborting the distal vertebræ, it makes much progress towards becoming *diphycercal*, but ceases to grow before it has quite accomplished this stage. The *Polypterus*, the eels, the *Gymnarchus*, and other fishes ossify the vertebræ in the isocercal stage. The *heterocercal* type is seen in the *Chondrostei*, where the vertebræ never ossify. In *Lepidosteus*, *Amia* and *Salmo*, they ossify in this stage.

I will now further specify the characters of the orders of *Physostomi*, and the families they contain.

Ginglymodi. Parietals in contact; pterotic simple; symplectic present. Mandible with coronoid, opercular, angular, articular and dentary bones. Basis cranii simple. Third superior pharyngeal bone small, lying on fourth; upper basihyal wanting. Maxillary subdivided. A præcoracoid arch. Vertebræ opisthocœlian. Pectoral fins with mesopterygium and five other basal elements.

One family, the *Lepidosteidæ*, with heterocercal tail, cartilaginous præcoracoid, one axial hyoid and three basal branchihyals.

Halecomorphi. Parietals in contact, pterotic basis cranii and anterior vertebræ simple. Mandible with opercular and coronoid; maxillary not segmented, bordering the mouth. Third superior pharyngeal lying on enlarged fourth; upper basihyal wanting. Vertebræ amphicœlian. Pectoral fins with mesopterygium and eight other elements.

One family, the *Amiidæ*, with heterocercal tail, cartilaginous præcoracoid, one axial and four basal branchihyals.

Nematognathi. Parietals and supraoccipital confluent. Four anterior vertebræ coössified, and with ossicula auditus. Nomesopterygium. Basis cranii and pterotic bone simple; no coronoid bone. Third superior pharyngeal bone wanting or small and resting on the fourth, second directed backwards. One or two pairs basal branchihyals, two pairs branchihyals. Suboperculum wanting, premaxillary forming mouth-border above. Interclavicles present.

This division is the nearest ally to the sturgeons (*Chondrostei*) among Physostomous fishes, and I imagine that future discoveries will prove that it has been derived from that division by descent. In the same way the Isospondylous fishes are nearest to the *Halecomorphi*, and have probably descended from some *Crossopterygian* near the *Haplistia*, through that order. The affinity of the cat fishes to the sturgeons is seen in the absence of symplectic, the rudimental maxillary bone, and as observed by Parker, in the interclavicles. There is a superficial resemblance

in the dermal bones. The rudimental mesopterygium shown by Gegenbaur to exist in the young *siluridæ*, the præcoracoid arch and the ventral fins, are shared with the sturgeons and other divisions.

There are considerable varieties of type in subordinate features to be observed in the Nematognathi. The *Hypophthalmidæ* are indeed scarcely to be referred to this order.

1 Anterior vertebræ modified; inferior pharyngeal bones distinct; few branchiostegal radii;
Operculum present. *Siluridæ.*
Operculum wanting. *Aspredinidæ.*

2 Vertebræ unmodified; inferior pharyngeal bones united their whole length many branchiostegal rays;
Operculum present, *Hypophthalmidæ.*

In the *Siluridæ* we have other modifications of importance. Thus in *Plotosus* the second superior pharyngeal is wanting. In *Loricaria* and its allies, the pterotic is greatly expanded, so as to unite with the hyomandibular and opercular bones.

Scyphophori. Parietals narrow, distinct from each other and the supraoccipital. Pterotic large funnel-shaped, enclosing a chamber which expands externally, and is covered by a lid-like bone. No symplectic. Opercular bones present. Anterior vertebræ unaltered. No mesopterygium. Basis cranii simple. No interclavicles.

This very distinct group is about equally allied to the preceding and the following. The arrangement of the parietal bones appears to explain that of the *Siluroids*, about which there is some difference of opinion among naturalists. Thus Huxley in his memoir on the Ganoids, in his figure of *Clarias*, labels these confluent elements (as I suppose them to be at present), supraoccipitals; Parker (shoulder girdle), calls them parietals. The families of this order are two, viz:

Tail isocercal, *Gymnarchidæ.*
Tail diphycercal, *Mormyridæ.*

In *Mormyrus* there is one vertebra of the original series left in the tail.

Plectospondyli, Parietals broad, distinct, pterotic normal, symplectic present. Opercular bones all present; no interclavicles. Anterior four vertebræ much modified and with ossicula auditus.

1 Brain case produced between orbits; only two superior pharyngeal bones; basis cranii simple.
a Only two basal branchihyals.
Tail diphycercal, *Catostomidæ.*
a a Three basal branchihyals,
Tail diphycercal, *Cyprinidæ.* *Cobitidæ.*
Tail isocercal, *Sternopygidæ.*

2 Brain case not produced between orbits, basis cranii double, with muscular canal in many; four to one superior pharyngeal bones.
Three basal branchihyals, *Characinidæ.* *Erythrinidæ.*

Isospondyli. Parietals separate, symplectic present; no interclavicles. Anterior vertebræ simple, unmodified. Pharyngeal bones separate above and below.

An extensive group, presenting many subordinate modifications.

1 Tail subisocercal; pterotic externally annular enclosing a large cavity; basis cranii double; *Notopteridæ.*

2 Tail diphycercal; pterotic normal, basis cranii double; superior pharyngeals four, distinct, third largest directed forward; basal branchihyals three: (typical.)

* Parietals united.

Two tail vertebræ, — *Hyodontidæ.* *Albulidæ.* *Elopidæ.*

One tail vertebra, — *Aulopidæ.* *Coregonidæ.* *Lutodiridæ.*

No tail vertebræ, — *Sauridæ.* *Gonorhynchidæ.*

* * Parietals separated by supraoccipital.

Two tail vertebræ, — *Alepocephalidæ.* *Salmonidæ.*

One tail vertebra, — *Chirocentridæ.* *Clupeidæ.*

3 Tail diphycercal, pterotic normal, basis cranii simple.

Basal branchihyals and superior pharyngeals each three; — *Osteoglossidæ.*

The same bones each two; — *Heterotidæ.* *Galaxiidæ.*

HAPLOMI. No praecoracoid arch. Parietal bones separated by the supraoccipital. A symplectic; opercular bones present; anterior vertebræ unaltered. Pharyngeal bones distinct, the superior directed forwards, three or four in number. No interclavicles.

1 Basis cranii double; maxillary entering mouth border. — *Esocidæ.*

2 Basis cranii simple; maxillary bounding mouth. — *Umbridæ.*

3 Basis cranii simple; mouth bounded by premaxillary only; third upper pharyngeal enlarged. — *Cyprinodontidæ.* *Hypsœidæ.*

GLANENCHELI. Parietal bones extensively in contact, distinct; pterotic normal; a symplectic. Opercular bones complete; mouth bounded by premaxillary chiefly: six or seven basilar pectoral rays. No præcoracoid or interclavicles. Anterior vertebræ united, modified, and with ossicula auditus. Superior pharyngeal bones subequal, continuous.

One family, the *Gymnotidæ*, which approaches the eel-like *Siluridæ*, the *Sternopygidæ*, and the *Monopterus* of Java, so as to be in a measure intermediate between them. The characters are, no parietal fontanelle; four superior pharyngeals, three basal branchihyals; brain prolonged between orbits. The structure of the fins, and the rudimental maxillary bones distinguish this family from the Sternopygidæ, with which they have been heretofore associated. In the first they are like the eels, in the latter the siluroids.

ICHTHYOCEPHALI. Epiclavicle suspended to posttemporal and to cranium; mouth bounded above by premaxillaries, which are in contact on the median line, and in contact with a distinct maxillary by the posterior margin; no interneural spines, pectoral fins nor symplectic bone; two basal branchihyal pairs. Vertebræ unaltered. Two pairs basihyals.

One family, the *Monopteridæ*. Two (3d and 4th) superior pharyngeal bones on each side. The general form is eel-like.

HOLOSTOMI. Epiclavicle suspended to fourth vertebra, posttemporal wanting. Parietals in contact. Mouth bounded by the premaxillaries which are in contact medially and bounded behind by maxillary. Symplectic present; vertebræ unaltered; no pectoral fin. Third superior pharyngeal not smaller than fourth.

One family, the *Symbranchidæ*, with the genera *Amphipnous* and *Symbranchus*.

ENCHELYCEPHALI. Parietals in contact; lower pair of basihyals wanting. Scapular arch suspended to an anterior vertebra, no posttemporal, no symplectic, maxillary bone absent or connate with premaxillary which forms border of mouth. Premaxillaries separated on the median line by the ethmoid. Superior branchihyals and inferior and superior pharyngeals well developed; the latter of three bones. Of these the fourth is largest and supports the third, which with the second is directed forwards.

1. Palatopterygoid arch complete; pectoral fins. — *Congridæ.*

2. Pectoral fins; palatopterygoid arch represented by pterygoid; premaxillaries more widely separated. — *Anguillidæ.*

3. No pectoral fins; no metapterygoid; pterygoid a slender rod; ethmoid much wider. *Gymnothoracidæ.*

Colocephali. Parietals largely in contact, opercular bones rudimental, the preoperculum generally wanting. Premaxillary rudimental or wanting; ethmoid very wide. Symplectic, maxillary, pterygoid, basal-branchihyal, superior and inferior pharyngeal bones all wanting, except the fourth superior pharyngeal. This is jaw-like, and supported by a strong superior branchihyal; other superior branchihyals wanting or cartilaginous.

This well marked order includes the eels of the family *Muræniдæ* (with *Gymnomuræna* etc).

It is evident from the above, that the eel-like form common to the last five orders is not more important in a systematic sense, than the fish-like form, which is common to so many of the others.

Physoclysti.

The following is an analytic synopsis of the orders. They all have the parietals entirely separated by the supra-occipital, and lack the præcoracoid, and have the symplectic present.*

A Scapula suspended to the anterior vertebræ.

Superior branchihyals and pharyngeals present, inferior distinct; maxillary distinct; no interclavicles. 15 Opistohmi.

A A Scapula suspended to cranium by a posttemporal.

I. Ventral fins abdominal.

Branchial arches well developed, the bones present, except fourth superior pharyngeal; third much enlarged. Inferior pharyngeals distinct. 16 Percesoces.

Third and fourth superior pharyngeals much enlarged, inferior pharyngeals coössified. 17 Synentognathi

Superior branchihyals and pharyngeals reduced in number; inferiors separated 18 Hemibranchii.

Superior branchihyals and pharyngeals, and basal branchihyals wanting; gills tufted. 19 Lophobranchii.

II. Ventral fins thoracic or jugular.

First vertebra united to cranium by suture; epiotics united behind supraoccipital; basal pecoral radii elongate. 10 Pediculati.

Posterior cephalic region normal, anterior twisted so as to bring both orbits on one side; inferior pharyngeals distinct. 21 Heterosomata.

Cranium normal, premaxillaries usually coössified with the maxillaries behind, and the dentary with the articular; pharyngeal bones distinct. 22 Plectognathi.

Cranium normal, bones of the jaws distinct; inferior pharyngeal bones distinct. 23 Percomorphi.

Cranium normal, bones of the jaws distinct; third superior pharyngeal much enlarged, articulated with cranium, inferior pharyngeals coössified. 24 Pharyngognathi.

These orders are more fully defined below, and the families which are referable to them pointed out.

Opisthomi. Scapular arch suspended to the vertebral column. Superior pharynegeals and branchihyals ossified, in the former third a little larger, followed by a small fourth. Three basal branchihyals, inferior pharynegeals distinct Maxillary bone distinct; supraoccipital separating parietals. No interclavicles. Symplectic present.

One family the *Mastacembelidæ*. In it, the tail is isocereal, spinous dorsal present, and the ventrals wanting. It bears considerable resemblance to the eels of the family *Symbranchidæ*.

Percesoces. Ventrals anteriorly or posteriorly abdominal. Mouth formed by premaxillaries; posttemporal furcate anteriorly, not suturally attached. Three basal branchihyals: all those of the superior series generally present. Superior pharyngeals with the third very largely developed, but not articulated to the cranium. Inferior pharyngeals distinct. Basal pectoral rays four, short. Basis cranii without muscular tube, but with rudimental upper floor.

* Except in *Ostracium*, where it is not ossified.

1. Dorsal fin of branched radii; no second floor of brain case; transverse wing on inside of hyomandibular; second superior pharyngeal rod-like, first present, third simple. *Opheocephalidæ.*

2. Dorsal fin of spinous and soft portion; no hyomandibular wing; second superior pharyngeal subconic, third very large of two horizontal laminæ, the superior supported by the inferior by a vertical rod. Superior branchihyals, second a triangular plate with supero-exterior process; third and fourth tri-radiate. *Mugilidæ.*

3. Dorsal fin of spinous and soft portions, ventrals more abdominal; third superior pharyngeal long and wide, simple, second rod-like. Basis cranii with upper floor better developed anteriorly. *Atherinidæ.*

The family of *Cyprinodontidæ* approaches the *Opheocephalidæ* very closely, differing as to ordinal characters, in the presence of the ductus pneumaticus. The form of the maxillary bone and anterior position of the ventral fins ally them to the *Mugilidæ*, while the enlarged third superior pharyngeal even exceeds that of the *Atherinidæ*. The physiognomy brings it into relation with this order.

SYNENTOGNATHI Mouth bounded by the premaxillary only; parietal bone very much reduced; posttemporal slender, furcate; supraclavicle not distinct. Pectoral fin with elevated basis; no interclavicle. Superior pharyngeals second and third large, oval, not articulated to cranium, sending processes forward; fourth wanting. Inferior pharyngeals coössified. Basis cranii double in front, but without muscular tube.

The only family of this order, the *Scomberesocidæ*, has a diphycercal tail, and no spinous dorsal fin. In its rather weak superior branchihyals it shows resemblance to the next order.

HEMIBRANCHII. Mouth bounded above by premaxillary only; posttemporal not furcate. Pectoral fins elevated; interclavicles developed. Superior pharyngeals small, weak; second, third, and generally fourth present; superior branchihyals rudimental, the fourth, and sometimes others, wanting. Inferior pharyngeals distinct. Branchial processes narrow laminæ. Basis cranii simple, no tube.

1. Anterior vertebræ but little enlarged; dorsal spines strong; first, second and third superior branchihyals and second and third superior pharyngeals present. *Gasterosteidæ,*

2. Four anterior dorsal vertebræ much elongate (centrum and spine united by suture in *Fistularia*), dorsal spines very weak, or none. *Fistulariidæ.*

α Superior branchihyals cartilage, three superior pharyngeals. *Aulostoma.*

β Three anterior superior branchihyals osseous, three superior pharyngeals, directed forwards. *Fistularia.*

3. Four anterior vertebræ much elongate, with strong diapophyses, and normal articulations.
Fourth superior branchihyal and first and fourth superior pharyngeals only wanting. *Centriscidæ,*

4. Six anterior vertebræ extremely elongate, with normal articulations of centra.
Fourth superior branchihyal and all the superior pharyngeals wanting. *Amphisilidæ.*

This very natural order connects the ordinary fishes immediately with the *Lophobranchii*. The family *Gasterosteidæ* is the least specialized of them, and presents some relationship to *Nematocentris*, a genus of *Atherinidæ*, from Australia. The latter has flat, transverse and serrate spinous rays to both dorsal fins, which both exhibit soft rays, as though in anticipation of their absence anteriorly in *Gasterosteus*. The relationships of this order to the *Lophobranchs* are numerous. They are, the weakening of the branchial apparatus, the presence of the interclavicles (which I find in all), the simplicity of the posttemporal bone and basis cranii, the shortness of the branchial processes the prolongation of the muzzle and the ganoid plates, are characters of subordinate relationship. On the part of the *Lophobranchii*, the *Solenostomidæ* approach this order, but to which family I am not sure, probably to the *Fistulariidæ*.

LOPHOBRANCHII. Mouth bounded by the premaxillary above; posttemporal simple, coössified with the cranium. Basis cranii simple. Pectoral fins with elevated basis; well developed interclavicles. Anterior vertebræ modified, the diapophyses much expanded. Inferior and superior pharyngeals and superior branchihyals wanting or unossified. Branchial processes in tufts.

1. A weak spinous dorsal fin. *Solenostomidæ.*
2. No spinous dorsal fin. *Syngnathidæ.* *Hippocampidæ.*

PEDICULATI. Basal radii of pectoral fin elongate, reduced in number; no interclavicles. Epiotics united with each other above behind supraoccipital, and the first vertebra with the cranium by suture; posttemporal broad, flat, simple. Superior pharyngeals two, similar, spatulate with anterior stem and transverse blade. Basis cranii simple.

Two families, the *Antennariidæ*, with three, and the *Lophiidæ* (*Lophius*, *Halieutæa*, *Malthe*), with two, basal pectoral radii. They connect with the *Percomorphi* by the *Blenniidæ* and *Batrachidæ*.

HETEROSOMATA. Cranium posteriorly normal; anteriorly with twisted vertex, to allow of two orbits on one side, or one vertical and one lateral; basis not quite simple; dorsal fin with jointed rays. Superior pharyngeals four, the third longest, much extended forward; inferiors separate.

Embraces the family of *Pleuronectidæ*.

PLECTOGNATHI; cranium posteriorly normal; the posttemporal coössified with the epiotic, and undivided. The elements of the mandible and usually the premaxillary and maxillary coössified. Interoperculum a slender rod. Superior pharyngeals laminar usually vertical and transverse.

1 Maxillary distinct, a suboperculum; sup. pharyngeals vertical, transverse, fourth present, minute; *Triacanthidæ*.

2 Maxillary coössified, a suboperculum; basis cranii double, with tube. Pharyngeals vertical transverse, fourth wanting; *Balistidæ*.

3 Maxillary coössified, a suboperculum and symplectic; basis cranii simple.

Pharyngeals transverse vertical, fourth present; *Tetrodontidæ*.

Do. more longitudinal, *Diodontidæ*.

4 Maxillary coössified; no suboperculum; symplectic not ossified; interclavicles present. Fourth sup. pharyngeal wanting, 2d and 3d forming a vertical subconic mass; *Ostraciontidæ*.

The contents of this order are heterogeneous, and it is questionable whether section fourth really belongs to it. The Plectognaths are associated with the true *perciform* fishes by *Triacanthus* on their part, and the *Acronuridæ* and *Chaetodontidæ* on the other. Their affinities have never been, in my estimation, heretofore properly expressed in the systems, where they have always been arranged at a distance from the higher *Physoclysti*. Yet the structure of the swim-bladder, skull, scapular arch, caudal vertebræ, pectoral fin, in fact, everything, combine to indicate their position to be here. The shortened jaws, especially the maxillary of *Acanthurus*, remind one of *Triacanthus*, and its closely united slender femora, approach those of *Balistes*. The coössification of the simple posttemporal with the cranium confirms the affinity.

PERCOMORPHI. Bones of the mandible distinct, maxillary distinct. Cranium symmetrical, epiotics normal; no interclavicles; posttemporal not coössified with cranium. Basal pectoral radii not enlarged; humeri suspended (generally) from the scapular arch. Basal branchihyals three, inferior pharyngeals distinct; superior pharyngeals with the third most generally largest. Sub and interoperculum present, plate-like.

This extensive order embraces a great variety of forms, some of which may yet be regarded as forming distinct orders. At present I am not sufficiently sure of their exact definition to admit them as such.

I. *Anacanthini*. Basis cranii simple, no tube; posttemporal bifurcate, scapular foramen between scapula and coracoid. Superior pharyngeals three, horizontal, third little larger. Dorsal fin, rays flexible, jointed. Includes the families *Gadidæ* and *Macruridæ*, both with isocercal caudal vertebræ.

II. *Haplodoci*. Basis cranii simple flat, posttemporal simple undivided. Scapular foramen in centre of scapula. Basal segments of pectoral fin five, elongate. Superior pharyngeals contracted, first and fourth wanting, third basin-shaped with second adherent. Dorsal fin with some spinous rays.

One family, the *Batrachidæ*,

III. *Scyphobranchii*. Basis cranii simple, no tube; posttemporal furcate. Superior pharyngeals shortened, fourth and first generally wanting, third large, basin-shaped, second generally scale-like or coossified with third. Scapula with median foramen. Dorsal radii usually soft. Families *Uranoscopidæ*, *Gobiidæ* (genera *Gobius Philypnus Eleotris*

Callionynus Periophthalmus Boleophthalmus, Amblyopus Trypauchen), *Blenniidæ* (*Zoarces Anarrhicas, Cryptacanthodes, Salarias, Centronotus, Cristiceps*), *Gobiesocidæ* (*Gobiesox Sicyases, Lepadogaster*); *Cottidæ* (*Uranidea, Cottus Leptocottus, Hemitripterus, Scorpaenichthys*).

IV. *Epelasmia*. Basis cranii double, with basal muscular tube; posttemporal undivided. Second, third and fourth superior pharyngeals transverse vertical laminæ. Scapula with median foramen; basal pectoral bones four, short. Dorsal spines strong. Families, *Acronuridæ*, (with *Amphacanthus*) and *Chaetodontidæ*, (with *Chaetodon, Chelmo, Zanclus, Platax, Heniochus*, (*Taurichthys*,) *Epibulus* and *Toxotes*).

V. *Rhegnopteri*. Basis cranii double with tube; posttemporal bifurcate; scapula with median foramen; superior pharyngeal bones four, third largest, narrow, directed forward. Basal pectoral bones divided; two normal, supporting fin; one longitudinal without rays, and one a plate on coracoid, supporting elongate rays. Dorsal spines. One family, the *Trichidiontidæ* (*Polynemidæ*).

VI. *Distegi*. Basis cranii double, with muscular tube. Posttemporal bifurcated, scapula with median foramen; basal pectorals three or four, short quadrate. Superior pharyngeal bones four, third always the largest, longitudinal, more or less elongate, not articulated to the cranium. Inferior pharyngeals separated. Dorsal fin with strong spines.

α Third extremely elongate, narrowed forwards; *Scombridæ, Xiphiadidæ. Trichiuridæ*.

β Third shorter, but narrow; *Berycidæ, Percidæ* in part.

γ Third nearly wide as long; *Percidæ* pt., *Sparidæ, Sciænidæ, Pristipomatidæ, Triglidæ* pt.

δ Third much enlarged into a grinder. *Sillaginidæ, Carangidæ* (Scyris, Blepharis, Lactarius, Drepane, Equula, Trachynotus), *Echeneidæ, Gerreidæ, Heterognathidæ, Amblodon, Liostomus* (4th wanting).

ε Third more or less basin shaped; *Pterois, Synanceia, Scorpæna, Pelor* (tube rudimental), *Peristedion, Trigla* (pts).

VII. *Labyrinthici*. Basis crainii double, with muscular tube. Superior pharyngeals without the fourth, third massive articulated to cranium, one or other of the superior branchihyals developed into vertical laminæ, often involuted. Inferior pharyngeals distinct. Dorsal fin spinous.

I. Second sup. pharyngeal present, superior branchials present, fourth greatly laminated.
Osphromenidæ.

II. Second sup. pharyngeal wanting; first sup. branchihyal with three laminæ.

α Second and third sup. branchihyals present. (Polyacanthus Anabas). *Anabantidæ*

β Second (and third?) sup. branchihyals wanting. *Helostoma*.

PHARYNGOGNATHI. Basis cranii double, with tube; basilar bones of pectoral, four, short. Scapula with median foramen. Cranium normal posteriorly; posttemporal bifurcated. Superior branchihyals not complicated; superior pharyngeals with the third greatly developed and attached by movable articulation to cranium, the others wanting or rudimental. Inferior pharyngeals solidly coössified.

1 Fourth superior pharyngeal rudimental, second slender toothless; first similar.
Embiotocidæ (7 genera).

2. Fourth wanting; second laminar, adherent to third, dentate: (probably 4th coössified with third), (3d not articulated to cranium in *Crenicichla*, first present in *Chromis* and *Heliases*). *Chromididæ*.

3. Fourth wanting;

* Second rudimental rod-like, third with fixed articulation to fourth sup. branchihyal. *Labridæ*.

** Second wanting;
Labridæ, ? *Crenalus, Odax, Gomphosus*.

4. Third only present, the opposites united, and with a sliding articulation on the much enlarged fourth super. branchihyal. *Scaridæ*.

With this order we close the series, and think that it has a general claim to stand at the head of the true fishes. It displays an aggregation of all the characters which distinguish the higher from the lower fishes, whether in refer-

ence to order, sub-class, or class. The fins in their position and attachments exhibit the most remote separation from their characters in the *Crossopterygidæ*. The base of the cranium is complex, and removed in construction from the simple parasphenoid floor of the lower divisions. The pharyngeal bones are more specially developed than in any other order. The elements of the support of the caudal fin are more thoroughly coössified than in any other except *Scombridæ* and the *Plectognathi*.

GENERAL OBSERVATIONS.

In tracing the affinities of the *Physostomi*, I have pointed out the relation between the *Chondrostei* and the *Nematognathi*, and the *Halecomorphi* and the *Isospondyli*. The series commenced with the cat-fishes may be continued into the *Mormyri* and then to the families of the *Plectospondyli*, where the series with altered vertebræ and with ossicula auditus, terminates. The *Characins* have, however, considerable affinity to the *Isospondyli*, especially in the type of their branchial bones. From the latter group we pass to the *Haplomi*, and thence to the *Physoclyst* groups. The eel-like groups form a special line. The *Glanencheli* have cranial characters of the orders with modified vertebræ, (*Nematognathi* and *Plectospondyli*,) with fins of the more typical eels. The latter show a steady approach in some points to the conditions characterizing the *Chondrostei*. The loss of the maxillary, of opercular bones, and of pharyngeal elements, reminds one of these, but in the loss of the premaxillary, and great development of the ethmoid in the *Colocephali*, we have features quite unique. The vertebral position of the scapular arch is the only shark character they possess: while, on the other hand, the *Holsotomi* are undoubtedly related to the *Mastacembelus*, a real *Physoclyst* with spinous dorsal fin. These relations are as yet entirely inexplicable.

The affinities among *Physoclysti* are more clear. Omitting the genus above mentioned, we find the four orders with ventral fins to form a true series, with a *Synentognath* variation, terminating in the greatly degraded order of *Lophobranchii*. The *Percesoces* give us our nearest connection with the groups with ventral abdominals, and lead at once to the *Percomorphi*. From this centre radiate many lines of affinity. One leads from the *Chaetodontidæ* through the *Acroneuridæ* to the *Plectognathi* by the similarity in the arrangement of the posttemporal and forms of the pharyngeal apparatus. An important division of the *Percomorphi* has the basis cranii simple and the branchial arches reduced above, viz: the *Scyphobranchii*. The *Cottidæ* are the most generalized family of the group, and lead on the one hand, to the *Triglidæ* of the *Distegi*, with which they are generally arranged,—and on the other, to the *Blenniidæ*. Some of the latter elongate the basal pectoral bones considerably, and lead to the *Batrachidæ* on the one side, where the number of these bones is increased, and on the other to the *Pediculati*, where the number is diminished. To these groups the *Anacanthini* and *Heterosomata* are also allied.

The third upper pharyngeal bone has already presented an increase of mass and use in the first orders of Physoclysti with the ventral fins. Among the *Percomorphi*, the same increase makes its appearance by little beginnings in some *Sciaenidæ*. It is quite noteworthy in most of the *Carangidæ*, a group whose separation from the *Scombridæ* by Gill, is supported by this part of their organism. Through forms not now specified, approach to the *Pharyngognathi* is made. Here the pharyngeals are modified into a mill-like structure, which is least specialized in the *Embiotocidæ*, and most so in the *Scaridæ*.

NAMES OF THE ORDERS.

Of the orders here proposed or adopted, a number have been employed in various senses by ichthyologists. I refer only to those who have defined their groups, as those who have merely given names cannot be understood as authors of anything but those names. A definite idea of the definition of a group involves the ability to characterize it, and by such process only can the idea entertained by the author of a division be determined by others.

The order *Nematognathi* was named and defined by Prof. Gill in 1861;* Prof. Agassiz has expressed his belief that the order was well established. Additions to its characters are now made. The *Synentognathi* was also proposed in 1859† as distinct from the Pharyngognathi, with which J. Müller had united it. The order of *Lophobranchii* is

* Proceed. Acad. Nat. Sciences, Philadelphia, in a "Catalogue of the Fishes of the Eastern Coast of North America."

† Loc. Cit. p. 148.

well known as Cuvier's, and has been generally adopted. Müller proposed the *Pediculati* with part of the definition here given. The *Heterosomata* were arranged together under this name and defined by Dumeril. The *Plectognathi* were first defined by Cuvier; while the *Pharyngognathi* a part only of Müller's order of that name, was defined by Gill, after the deduction of the *Synentognathi*.

II. CATALOGUE OF SPECIES.

PHARYNGOGNATHI.

Pomacentridæ.

MICROSPATHODON CHRYSURUS, Cuv. Val. V., 476, *Microspathodon*, Gthr.

St. Croix, Dr. Griffith; St. Martins, Dr. Rijgersma.

GLYPHIDODON SAXATILIS, Linn., Cuv. Val. V., 446, Gthr., Catal. B. M., iv., 35.

St. Martins, Dr. Rijgersma; St. Croix, Thos. Davidson, Dr. R. E. Griffith; New Providence, Dr. Wood.

POMACENTRUS LEUCOSTICTUS, Müll. Trosch. in Schomburgk's Nat. Hist., Barbadoes, 674. Günther Catal. B. Mus. iv., 31.

St. Croix, Capt. T. Davidson; St. Martins, Dr. Rijgersma; New Providence, Dr. Wood.

Gerridæ.

GERRES GULA, C. V., vi., 464. Günther Cat. B. M. II., 346.

St. Martins, Dr. R. E. van Rijgersma; St. Croix, Thos. Davidson, Dr. R. E. Griffith.

Scaridæ.

SCARUS GUACAMAIA, Cuv. Val. XIV., 178. *Pseudoscarus*, Günther Cat. Brit. Mus. iv., 233.

St. Martins, Dr. Rijgersma.

SCARUS CHLORIS, Bloch Schn., *Pseudoscarus*, Günther Catal. iv., 227.

New Providence, Bahamas, Dr. H. C. Wood.

SCARUS SANCTÆCRUCIS, Bloch., *Pseudoscarus*, Günther Catal. iv., 226. *Scarus alternans* C. V., xiv., 200.

St. Croix, Dr. R. E. Griffith.

SCARUS TAENIOPTERUS, Desmarest, Cuv. Val. XIV., 195, *Pseudoscarus* Gthr. Catal., IV., 226.

Santa Cruz, R. E. Griffith, M. D.

SCARUS DIADEMA, Cuv. Val. XIV., 146. Poey Rep. Cuba ii., p. 347. Guichenot Catal. Scari Mus. Paris, Proc. Cherbourg.

This species, placed as a synonyme of the last with question, by Günther in the Catal. Brit. Mus. iv., p. 226, is as distinct from it as the allied species are from each other. A fresh specimen from Dr. Rijgersma enables me to describe the colors of this very handsome fish as follows:

General color of anterior half of the body, crimson; of the posterior, golden. All the scales with a red-orange border. An orange band from mouth to orbit, margined by green above and below, the lower continued to opercular lobe and round chin behind a red band. Temple greenish; golden of posterior parts continued as a band to the base of the pectoral. Caudal slightly rounded, the angles not prolonged, the superior and inferior margins green. Dorsal and anal fins, with dirty green margins, yellow-edged within, and very narrow green basis with inner yellow margin. Numerous transparent, dirty green spots on intermediate space of anal and posterior two-thirds of dorsal. Six rows of scales on the middle series of the cheek.

When the specimens are bleached in spirits, the species is best distinguished from the *P. taeniopterus* by the spotted fins, as well as the lack of dark lateral band, and six cheek scales.

St. Martins, Rijgersma; St. Croix, Davidson and Griffith.

SCARUS PSITTACUS, Linn., *Pseudoscarus*, Günther Catal. 225. *Scarus vetula*, Bloch, Cuv. Val. XIV., 193.

St. Martins, Rijgersma; St. Croix Dr. Griffith.

SCARUS AUROFRENATUS, Cuv., Vol. XIV., 191. Gthr. Cat., iv., 212.

St. Croix, Dr. Griffith; St. Martins, Dr. Rijgersma.

SCARUS CHRYSOPTERUS, Bl. Schn. Cuv. Val. XIV., 185. Gthr. Catal. IV. 211.

St. Croix, Dr. Griffith; St. Kitts, B. H. Lightfoot.

SCARUS RADIANS, "Cuv. Val." Günther Cat., B. Mus., iv., 211.

Several specimens which agree with Günther's description, but not with any of Prof. Poey's.

St. Martins, Dr. Rijgersma.

SCARUS HOPLOMYSTAX, Cope Sp. nov.

This species agrees with the description given by Günther of what he considers to be the young of the last species. It is clearly not the young of *S. radians*, nor of any of the species described by Günther or Poey. It is nearly allied to the *S. lachrymosus* and *S. atomarius* of Poey, (Repert. Fis., etc., Cuba. II., 343,) in having prominent divergent acute teeth external to the confluent series of the upper jaw. This character is evanescent in *S. chrysopterus* and *S. abildgaardii* as indicated by our specimens, but would indicate another genus were it constant. Our specimens of *S. radians* (above) are of the same size as those of the present species, and display no trace of external teeth, five of the former being compared with the latter. The *S. radians* display the caudal fin openly emarginate, the *S. hoplomystax* rounded. In the former, there are obscure cross-bands with scattered red scales, in the latter a broad longitudinal band, with red below it. This band extends from the orbit to near the caudal fin including two and two half rows of scales. There are four equidistant pale spots in its course, a silvery band round the chin. Three brown spots on the dorsal fin; other parts of that and the caudal punctate with white and brownish, a row of small white dots on pectoral, round the basis. Anal fin with white variations and three vertical brown spots, four in some,—obscure in others. A very faint spot at the base of the pectoral, wanting in some; it is quite distinct in *S. radians*.

Orbit, five times in head, nearly twice in muzzle; depth, 3 2 times in total length; head, four times. Free teeth, three on each side, the anterior directed to the opposite, the posterior outwards to the same side; the latter quite long and sharp. Marginal teeth, very minute, those of the mandible larger, three rows with crowns nearly distinct. Length, five inches.

St. Martins, Dr. R. E. van Rijgersma.

This species differs from the *S. lachrymosus* of Poey in having six instead of four free maxillary teeth, and nine soft anal radii. The color must be quite different, as Poey mentions none of the peculiarities of this fish, and says there is a blue band from the orbit to the lip, which I have not seen in it. In *S. atomarius* the orbit enters a little over four times the length of the head, and the caudal is vertical, not rounded. The coloration, from Prof. Poey's description is quite different; he connects also one more anal ray, but he may include the posterior half of the last.

St. Martins, Dr. Rijgersma. Many specimens.

SCARUS RUBRIPINNIS, Cuv. Val. XIV., 199.

St. Croix, Dr. Griffith, (six inches long.)

SCARUS ABILDGAARDII, Bloch. Cuv. Val. XIV., 175; Günther, IV., 210.

New Providence, Bahamas, Dr. Wood; St. Martins, Dr. Rijgersma; St. Croix, Dr. Griffith.

SCARUS, sp. indet.

St. Croix, Dr. Griffith.

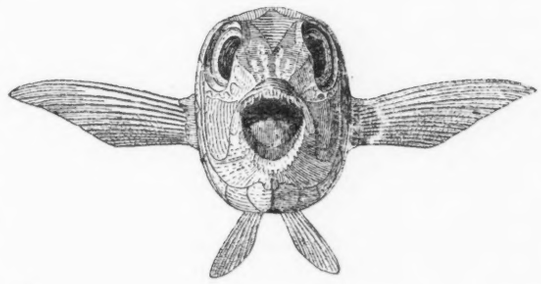
CRYPTOTOMUS ROSEUS, Cope, gen. et. sp. nov.

Char. gen. Interior series of teeth in both jaws consolidated into a single cutting body on each side, the exterior series entirely free in front, wanting on the sides. Spinous Rays, D. XI. A. III.; the dorsal flexible, terminating in filaments, and united by membrane at the base only. One row of scales on each cheek. Lips, double at the sides only.

This genus has the dentition of *Callyodon* with the numerous dorsal and anal spines of the group of *Harpe*. The pharyngeal teeth are identical with those of *Callyodon*.

Char. specif., scales $1\frac{1}{2}$—23—6; radii D. XI. 8; A. III. 8., p. 12. The ventrals are short, extending half-way to the vent; the pectorals extend three-quarters the same distance; caudal truncate. One large scale between pectoral and ventral; scales of opercles, very large; preopercular limbs, naked; cheek with a series of three scales, which are caducous.

General form like that of Julis, elongate; depth into total length, four and a half times; length of head into the same, three and one-third times. The extremity of the maxillary bone in its sheath does not quite reach the anterior line of the orbit. The free teeth are closely appressed to the solid mass beneath and are included in two alternating rows anteriorly.



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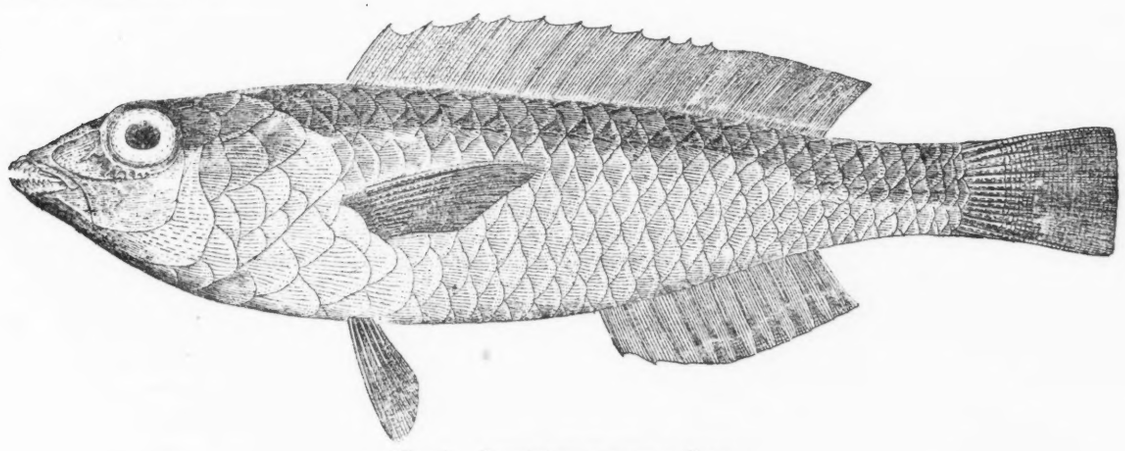

Fig. 1. Cryptotomus roseus, Cope.

They all project in the line of the front and of the mandible, the superior overlapping a little the inferior. The diameter of the eye enters the length of the head including teeth, five times; the muzzle 1 4-5 times, and the interorbital space ·75 of a time. The front is flat, and the muzzle sufficiently so to produce a slight canthus rostralis. Its profile descends gradually straight to the teeth.

The color is rosy purple, most purple on the cheeks; below, fading into light orange. Scales of the superior row, brown bordered. Caudal fin, yellow.

St. Martins, D. R. E. van Rijgersma.

Labridæ.

Cossyphus rufus, Linn, Günth., catal. B. M. IV., 108, *C. bodianus*, Cuv. Val. XII., p. 103.

New Providence, H. C. Wood, M. D. St, Croix, Dr. R. E. Griffith.

Clepticus genizarra, Cuv. Val. XIII, 267. St. Croix, Dr. Griffith.

Platyglossus bivittatus, Bloch., Günth., Catal IV., 164. *P. psittaculus*, C. V. XIII., 387.

St. Martins, Dr. Rijgersma.

Platyglossus internasalis, Poey, Mem. Cuba II., 421. Günth. l. c., IV., 164.

St. Martins, Dr. Rijgersma.

Platyglossus crotaphus, Cuv. Val. XII., 395. Gth. l. c., 163.

St. Croix, Capt. Davidson.

PLATYGLOSSUS RUPTUS, Poey, Mem., Cuba, II., 212. Günther, l. c. IV., 162.

St. Croix, Dr. Griffith and Capt. Davidson.

PLATYGLOSSUS CYANOSTIGMA, Cuv. Vol. XIII., 391. Gth. l. c. IV., 161.

St. Croix, Dr. Griffith.

LACHNOLAEMUS FALCATUS, Linn. (Labrus). Günther Cat. Brit. Mus. IV., 87. *L. aigula*, Cuv. Val. XIII., 277. Lub. 378.

New Providence, D. H. C. Wood.

Malacanthidæ.

MALACANTHUS PLUMIERI, Bloch., Cuv., Vol. XIII., 319. Tab., 380. Günther Catal. III., 359.

St. Croix, Dr. R. E. Griffith.

PERCOMORPHI.

Distegi

Berycidæ.

RHINOBERYX CHRYSEUS, Cope Sp. Nov.

In this fish, the muzzle projects a very short distance in advance of the premaxillary border, and is therefore referred to the same genus as the *Rhynchichthys brachyrhynchus* of Bleeker, as proposed by Gill, though without entire confidence, as I have not seen the latter species.

The premaxillary groove open in *Myriopristis*, is here over-roofed and closed by the extension of the bones of the front; the spines of the premaxillaries are very short. On the vertex is a short supraoccipital corona. In front of and on each side of this, two approximated crests rise, which extend to the end of the muzzle. They enclose a groove which is narrower and deeper on the anterior half the cranium. External to these, a low ridge extends from each pterotic region, parallel to the other. Above the posterior border of the pupil they diverge to the front margin of the orbit and then converge to the end of the muzzle. A bony thickening on each side marks the union of these ridges with the median. From this a strong ridge extends along the posterior margin of the preorbital bone, enclosing in the angle with the lateral, the nares. Its edge is serrate, as is also that of another high crest on its front edge. Post frontal region, ridged; four teeth on posterior rim of orbit. Preoperculum, serrate coarsely behind and below, with rudimental spine at angle. Interoperculum, suboperculum, and operculum serrate, the latter with one submedian spine. Clavicle, epiclavicle and "posttemporal" toothed. Eye 2·6 times, interorbital width 3 times, in length of head. Last 3·2 times in length to basis of caudal; depth in same 2·75 times. Scales 3—38—7. Fin rays D. XI. 14; A. IV. 13; V. I. 7. Caudal peduncle, very short and slender. Last dorsal spines, short; second, elongate,

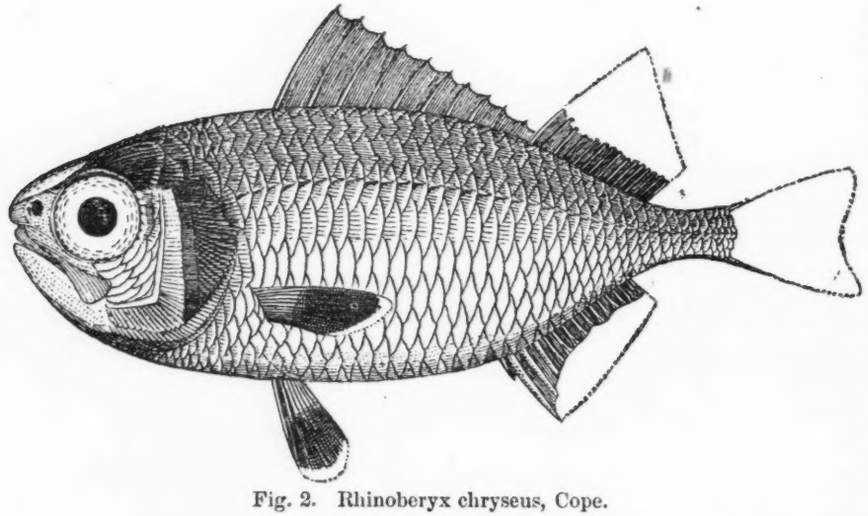

Fig. 2. Rhinoberyx chryseus, Cope.

exceeding the others, and equalling width of operculum and orbit to pupil. Length 2.5 inches. The color is golden excepting the superior three rows of scales and and posterior half the vertex, which are reddish. Spinous dorsal membrane with bright pigment (? red). Two specimens from St. Croix from Thos. Davidson.

MYRIPRISTIS JACOBUS, Cuv. Vol. III., 162. Günther Catal. I. 19.

St. Martins, (?) R. E. van Rijgersma, M. D.; St. Croix, Dr. R. E. Griffith.

HOLOCENTRUM SICCIFERUM, Cope, sp. nov.

Depth 2.6 times in length, exclusive of caudal fin; length of head (with spines) 2.75 in same; eye 2.6 times in head and .75 in interorbital width. Radii D. X 1, 13; A. IV., 9. Scales 3—45—8. Spinous dorsal rather short, elevated; last spine very short, only connected with first soft ray within the groove. Second dorsal not elevated, first rays equal 1.25 longest spines. Third anal ray not reaching basis of caudal: scales bordering anal fin, prolonged into grooved blades; body scales strongly pectinate not grooved. The muzzle is contracted especially laterally, the maxillary reaching the anterior margin of the pupil. Anterior supernumerary maxillary minute. Operculum finely denticulated, opercular spines two, equal, elongate; a pair of smaller spines at summit of operculum. One spine directed backwards at front of preorbital bone, all the lateral bones serrate. Interorbital carinæ very weak. Ventral fins not reaching vent. Length 2.75 inches.

Color in spirits silvery. A brown longitudinal band between each two rows of scales, to middle of sides; below this, brown punctae in the same position. Head brown shaded. Fins white, except first dorsal which is blackish; the membranes from I. to III. spines black with white or pale spots at base and one at margin. Chin brown.

New Providence, Bahamas, Dr. H. C. Wood.

This species, differs in many points from *H. longipinne* of the same size, viz: the wider interorbital space, narrower muzzle, upper pair of opercular spines, free opercular serration, deeper body, color, etc. It differs in coloration from the species described by Poey, who also does not mention any of the peculiarities of this fish in any of them.

HOLOCENTRUM LONGIPINNE, Cuv. Val. III., 185. *H. matejuelo* Bloch., Poey, Synopsis, 366.

St. Croix, R. E. Griffith, M. D., Capt. Davidson; St. Martins, Dr. R. E. Rijgersma; New Providence, Dr. H. C. Wood.

Percidæ.

APOGON STELLATUS, Cope. *Apogonichthys stellatus*, Cope, Transac. Amer. Philos. Society, 1866, 400.

New Providence, W. I., Dr. H. C. Wood.

BRACHYRHINUS CREOLUS, Cuv. Val. II., 265. Güthr. Catal. B. M., 100. Poey, Synopsis, 363.

St. Croix, Dr. R. E. Griffith, Capt. Thos. Davidson.

TRISOTROPIS UNDULOSUS, Cuv. Val. II., 143. Gthr. Catal. 143. Perhaps rather the T. cardinalis of Poey.

St. Martins, Rijgersma. St. Croix, R. E. Griffith.

EPINEPHELUS LUNULATUS, Bloch, Steindachner Verhand. Bot. Zool. Ges. Wien, 1866, 15 Tab. XIV. f. t.

St. Martins, Dr. Rijgersma; St. Kitts, Benj. H. Lightfoot; New Providence, H. C. Wood, M. D.

EPINEPHELUS CHALINIUS, Cope, sp. nov.

D. XI. 16. A. III. 10; pectorals attaining vent, caudal regularly rounded. Dorsal spines graduated, not elongate; membrane of both dorsals covered with small scales .66 to .75, its extent. Two opercular spines, the upper quite weak. Preoperculum with straight posterior margin, which is finely and sharply serrate: angle with five larger spines. Eye 4.25 times in head; head 3.5 in total (with caudal). Chin prominent. Mandible, pre and interorbital region with minute scales; maxillary bone scaleless; scales of operculum twice as large as those of cheek. Scales sharply ctenoid, 19 rows above lateral line at fourth dorsal spine.

Chocolate brown, paler below; below the lateral line six irregular undulate longitudinal darker lines, which are interrupted on the belly, and more or less confluent on the caudal peduncle. Above the lateral line these marks are

broader and more confluent. The paired fins blackish, 1st dorsal with pale base, soft dorsal with dark bordered, large pale spots at base. Three dark bands radiate from orbit to opercular margin, the middle one bifurcating. A similar band from preorbital across cheek. Throat unspotted.

St. Martins, Dr. R. E. van Rijgersma.

EPINEPHELUS STRIATUS, Bloch.

New Providence, Bahama Is. ; St. Croix, Dr. R. E. Griffith.

EPINEPHELUS ORDINATUS, Cope, sp. nov.

Radii D. XI. 16. A. III. 8. Dorsal spines subequal. Caudal fin rounded ; pectorals and ventrals subequal, extending a little beyond vent. Eye 4.25 times in length of head. Head 3.5 in total length ; depth not quite four times in the same. Preoperculum with convex, sharply serrated margin, and three coarser teeth at the angle. Three opercular spines, the superior obsolete. Scales on mandible and muzzle. Twelve rows above lateral line at V dorsal spine. Length six inches.

Brown, two darker subquadrate spots at origin dorsal fin, the first marking four interspaces, commencing at R. III; the second measuring three, commencing at D. IX. A black spot across caudal peduncle above, as in *S. striatus*. A large yellow or red spot between the dorsal spots and one behind the second, and three rows of the same on the sides. The upper row of two, large and distant ; second, of three smaller ; the third, of six or seven; smaller still, and near the belly. A similar spot behind upper angle of pectoral and several on head and jaws. The paired fins with broad dark margin ; caudal and anal with narrow light margin outside of this.

From Panama. Found by Dr. W. S. W. Ruschenberger, Prest. Academy Natural Sciences.*

This species appears to be allied to the *S. niveatus*, Cuv. Val.

SERRANUS CORONATUS. Cuv. Val. II., 371. Gthr. Catal. B. M., 124.

St. Croix, R. E. Griffith ; New Providence, Bahamas, H. C. Wood, M. D.

SERRANUS OUATALIBI. Cuv. Val. II., 381. Gthr. Catal. B. M., 120.

New Providence, H. C. Wood ; St. Kitts, B. H. Lightfoot ; St. Croix, R. E. Griffith and Capt. Thos. Davidson.

SERRANUS GUATIVERE. Cuv. Val. II., 384. Poey, Synopsis, Pisc. Cub., 364.

New Providence, H. C. Wood, M. D.

PLECTROPOMA CHLORURUM. C. V.

St. Croix, Thos. Davidson and Dr. R. E. Griffith.

PLECTROPOMA GUTTAVARIUM. Poey. *P. melanorhina*, Guich. Sagra's Cuba., I. f. 1.

St. Croix, Dr. R. E. Griffith.

PLECTROPOMA CROCOTA. Cope, sp. nov.

Form gibbous ; depth 2.2 in length without caudal ; length of head three times in same. Eye 3.5 times in head. (including spine) 5.4ths of interorbital width. Anterior rays of soft dorsal little more elevated than last rays of spinous fin. Radii D. X. 15. A. III. 7. Ventrals to anal ; pectoral to first soft ray of anal ; caudal moderately emarginate.

Front concave in profile ; muzzle a little longer than an orbits diameter. Eight equal teeth on the lower limb of the preoperculum. End of maxillary to line of posterior margin of pupil. Scales 12——81——32. Length 4.5 inches.

*EPINEPHELUS BRACHYSOMA. Cope, sp. nov.

Radii D. XI. 15. A. III. 8. Preoperculum slightly convex, with two short coarse teeth at angle. Three opercular spines well developed. Dorsal spines long; fourth (longest) nearly equal muzzle and orbit. Eye 5.25 in head ; head 3.33 times in total length. Depth body 3.5 times in same. Two scales on mandibles and maxillæ ; minute ones on preorbital alone. Rows above lateral line, 15. Caudal fin gently convex : pectoral and ventral equal, reaching vent. Length, eight inches.

Color in alcohol pale reddish brown, with numerous pale, (probably red in life) spots on the middle and lower parts of the sides, which are half to quarter as large as the pupil. A blackish band from preorbital bone above maxillary to the end of the latter. Just below its extremity a white (red) band extends in the same line to the interoperculum. No other marks on the head. All the fins except first dorsal broadly blackish bordered; the latter narrowly bordered by the same. The ventral membrane contains a pigment probably brilliant in life.

Rio Janeiro, Brazil. Dr. W. S. W. Ruschenberger's collection.

The species is not unlike the S. dichropterus in characters, but it has the ray formula XI. 17.

Color saffron yellow, becoming orange on the caudal, anal and vertical fins. Dorsal region becoming brownish anteriorly. A narrow blue band from front of orbit posteriorly on cheek, and some small blue spots on side of muzzle ; a narrow blue line along upper edge of preoperculum ; two faint vertical lines, on perculum. Dorsal and opectoral fins and jaws saffron yellow.

This brilliant species was found it at St. Martins, W. I. by Dr. R. E. van Rijgersma.

ALPHESTES MONACANTHUS. Mull. Trosch.

Plectropoma, Gthr., Catal I. 164. *Prospinus chloropterus*, Poey, Synopsis, 364, *Pristipoma chloropterum*, Cuv., Val. *Alphestes afer*, Bloch, Fide, Peters.

St. Martins, Dr. R. E. van Rijgersma.

RHYPTICUS SAPONACEUS, C. Val., Gill, Proc. A. N. Sci., Phil., 1861, 52.

St. Croix, Dr. R. E. Griffith.

ELEUTHERACTIS CORIACEUS. Cope, *gen. et sp. nov.*

Char. Gen. Subfam. Rhypticinæ. Dorsal fins entirely separate , dorsal with three spines, anal with none.

In the species, which is the type of this genus, the dorsal fins are far more distinct than in the *Promicropterus maculatus*, and the membrane between the dorsal spines is very low. As no species with III spines presents such a

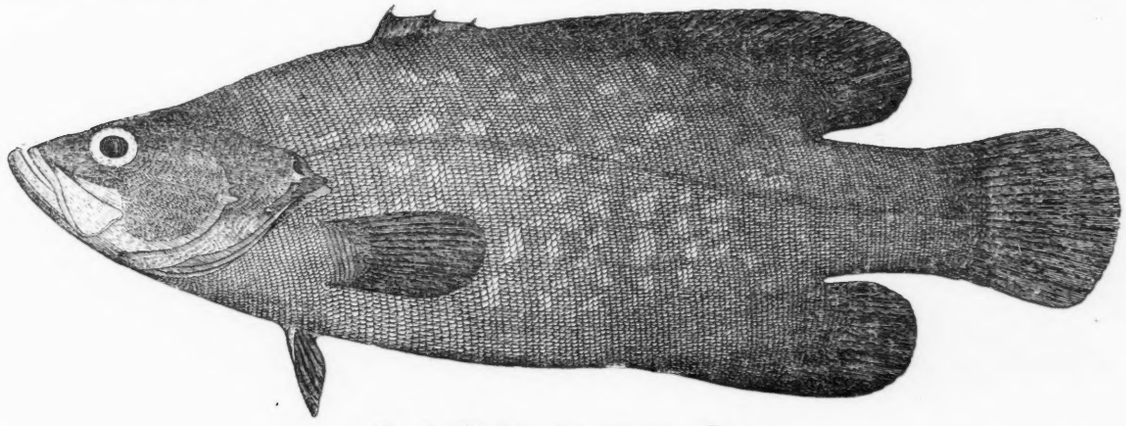

FIG. 3. Eleutheractis coriaceus. Cope.

separation, and it is doubtful whether those possessed of two have not the dorsals more or less confluent, I have regarded this group as distinct from either.

The allied species, *P. decoratus*, Gill, besides differing much from the *P. maculatus*, in color, has as complete a connection between the two dorsal fins as in *R. arenatus*. This connection is not wanting in a specimen of *P. maculatus*, presented to the Acad. Natural Sciences by Dr. Holbrook ; so that the separation of the fins, originally assigned by Gill, as the character of his Promicropterus, falls to the ground. This appears to be the opinion of Gill, also, since in his last useful synopsis of the group,* he transfers *P. nigripinnis*, Gill, with united fins, to it, on account of the II dorsal spines.

Char. Specif. Lateral line very slightly elevated in front ; twenty-one rows of scales between its convexity and the basis of the first dorsal ray. Greatest depth 3.33 times in length, including caudal fin. Head narrowed to the muzzle ; front concave ; eye anterior ; chin very prominent. Eye 5.5 times in length from premaxillary border to end of opercular spine ; 1.1 times in muzzle. Posterior angle maxillary, barely to posterior line of eye, posteriorly. Radii D., III., 25 ; A, 15 ; P., 16 ; V., I., 5. Extremities of 2 D. and A. extending to the basis of the caudal fin. Caudal rounded. Pectoral fin expands to a width equal to the length. Second dorsal originating opposite to the end of the pectoral. Scales, l. tr., + 19 — 43.

* Proceed. A. N. Sci., Phil., 1863, 163.

Color dark reddish brown; distal halves of the fins, except ventrals, black, with narrow yellow margin. Thorax, chin, and jaws brown punctate. Sides with irregular pale brown spots, not extending on fins and belly. Dorsal region and head immaculate.

Length ten inches. The two opercular, and one preopercular spines, bifid on one side.

From St. Martins, W. I. Discovered by R. E. van Rijgersma, M. D., among other interesting Zoological materials.

In determining this species I have had recourse chiefly to the published investigations of Gill, as he has developed this group more fully than any other zoologist.

ELASTOMA MACROPHTHALMUM, Müll. Trosch. *Centropristis*, M. T. *Anthias*, Günther.

St Kitts, B. F. Lightfoot.

PRIACANTHUS MACROPHTHALMUS, Cuv. Val. III, 97; Günther Cat., B. M. V. I, 215.

St. Croix, R. E. Griffith, M. D.

Sparidæ.

OCYURUS CHRYSURUS, Bloch, *Mesoprion chrysurus* Auctorum. *Ocyurus*, Gill.

St. Martins, Dr. Rijgersma; New Providence, Dr. Wood; St. Croix, Dr. R. E. Griffith, Capt. Thos. Davidson.

OCYURUS RIJGERSMAEI, Cope, sp. nov.

A large species, especially notable for the elevated carination of its front, and the elongate lobes of the caudal fin.

Length of head less than depth of body, entering 4.5 times the total length. Depth at orbit equal length to preoperculum; eye 5.66 times in length of head—nearly twice in muzzle. A section of the front would be parabolic, as

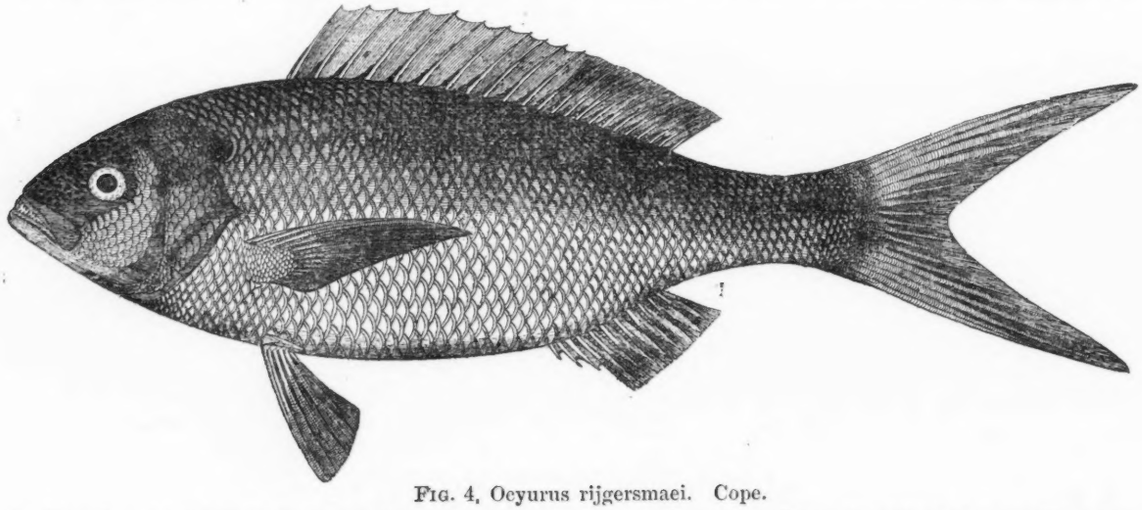

FIG. 4, Ocyurus rijgersmaei. Cope.

in *Coryphaena;* its elevation above the eye is equal to one eye's diameter. The extremity of the maxillary bone does not attain the line of anterior margin of the orbit. Maxillary scaleless; cheek with five rows. Preoperculum distinctly openly emarginate. Depth of body, one fourth total length; it is 2.66 times the depth of the caudal peduncle, which is thus slender. Scales large, 6—49—15 to anus. Caudal deeply forked; the forks lanceolate; the superior longer; both scaled to near the extremity; its length (to base of superior marginal ray enters the total length 3.3 times. Dorsal and anal fins scaleless, radii; D. XII, 12; A. III, 9; C. 2.18.2., P. 14. Pectorals falcate, reaching vent; ventrals three-fourths as long.

Three short canines on each side; vomerine patch anchor-shaped; an oval patch on the tongue. Serration of preoperculum obsolete, except on angle.

Total length, 0m·53; to orbit, 0m·039; to end of opercular bone, 0m·105; to basis of pectoral (line), 0m·11; to line of first dorsal, 0m·117; to origin of second dorsal, 0m·23; to origin of anal, 0m·242; to end of second dorsal 0m·293; to fork of caudal, 0m·424.

Color in life bright red, with a broad purplish brown band from the end of the muzzle, through the orbit to the caudal fin, occupying at first 1.5 rows of scales, and finally the upper half of the caudal peduncle to the end of the basis of the second dorsal. Six dark bands, formed by lines with intervals of ground color, extend from above the lateral line to the dorsal fin, the posterior too transverse, the anterior more oblique. They are more distinct at the base, where they form open spots. A large blotch of the same above the axilla. The top of the head to the end of the muzzle and the sides above the opercula are spotted with the same. In life, this color was brilliant—probably brownish purple; but my attention having been withdrawn from the specimen, the action of spirits has injured it, and I cannot recall the exact tint.

From St. Kitts, from the collections of Benjamin H. Lightfoot.

This is a large and magnificent fish, and apparently nearly affined to the O. chrysurus. It has a similarly graceful form, but exceeds it in the length of the tail and slenderness of the peduncle (the former is 4.33 times in the length in the latter). It differs in many other details, and in color. Among the former may be mentioned the shorter muzzle, smaller eye, high frontal keel, and more oblique mouth. The scales are less numerous, and the dorsal spines more so. It differs in much the same way from the two allied species described by Poey, *O. ambiguus* and *O. elegans*.

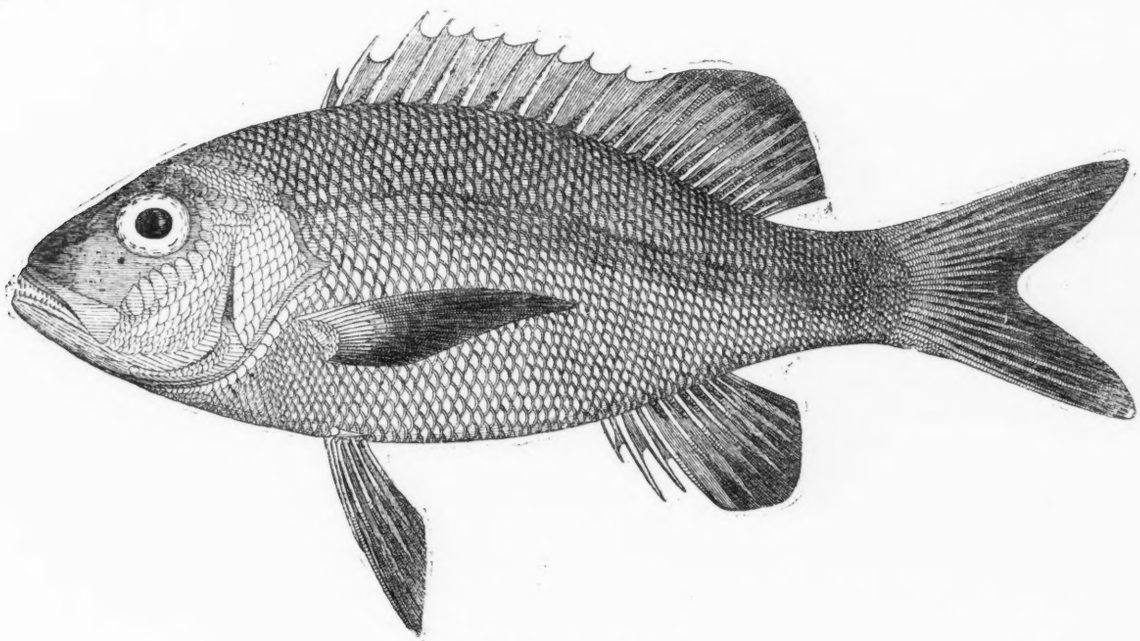

FIG. 5. Ocyurus torridus. Cope.

LUTJANUS TORRIDUS, Cope, sp. nov.

Radii, D, X. 13; A. III. 8. Scales, 7—46—20. Form stout; dorsal region gibbous; depth into length without caudal, 2.66 times. D. IV and V longest; soft rays gradually lengthening; emargination slight; last soft rays of D and A short. Caudal emarginate to one-third its depth, with narrow acute lobes. Pectorals and anals falcate; the former to anal fin, the latter to vent. Muzzle moderate; eye large, four times in length head. No opercular

spines; opercular and cheek scales equal. Preoperculum strongly serrate behind and half way below, with open margination posteriorly. Occipital crest very high, continued with supraorbital crests to front line of orbits. Premaxillary bone with three canines and a row of large teeth externally on each side; denting with several equal large teeth, anteriorly and medially. End of maxillary marking anterior third of orbit, not scaled. Total length, fourteen inches.

Color, a uniform bright crimson, a narrow sienna brown margin to the caudal fin, and line of similar color along the base of the dorsal on the second row of scales. The first is blackish in alcohol, the second much faded.

This very handsome species is like the *Anthias macrophthalmus* in external appearance, but may be soon distinguished. It attains some size.

From St. Kitts, C. H. Lightfoot:

LUTJANUS UNINOTATUS, Cuv. Val. II., 479; Günther I, 202; Poey, Synopsis, 365.

St. Martins, Dr. R. E. van Rijgersma.

LUTIANUS VIVANUS, Cuv. Val.; Gthr. I, 203.

New Providence, Bahama Is., H. C. Wood, M. D.; St. Croix, Dr. R. E. Griffith.

LUTJANUS ARNILLUS, Poey, Memorias II., 154; *Apsilus dentatus*, Guichenot, in De la Sagras Cuba 160, Tab., I, f. 1.

St. Croix, Dr. R. E. Griffith.

LUTJANUS GRISEUS, Cuv. Val.; Poey; Gthr, I., 194.

St. Kitts, P. H. Lightfoot; St. Croix, Dr. R. E. Griffith.

LUTJANUS BRACHYPTERUS, Cope sp. nov.

Scales smaller, 8—57--16. Radial formula D X. 12; A, III, 8; muzzle intermediate in relative length; the preorbital bone wide. One only moderately strong canine tooth on each side. Eye four times in length of head, equal interorbital width. Extremity of maxillary reaching beyond line of anterior margin of pupil. Profile straight not concave. Preoperculum with a wide open emargination, above which it is minutely below, coarsely serrate; interopercular, knob distinct. Cheek with the posterior—inferior half scaled; maxillary smooth. Third and fourth dorsal spines longest; equal muzzle to orbit. Pectorals reaching little beyond vent; ventrals not reaching vent; D, 2, and A not reaching base of caudal. Caudal openly emarginate; basal half scaly. Suprascapula only serrated.

Length, twelve inches. Depth, 3.6 times in length (with caudal). Length of head about the same. General color, yellow olivaceous, each scale with a dark spot at the base. Head sides, golden; top, gray.

This species differs from all those represented by L. griseus, in its shorter, D. 2, having 12 instead of 14 rays. In its medium number of scales and shorter muzzle it is nearest *L. buccanella*; but besides the difference in D. 2, the form is more elongate, and there is no black spot at the base of the pectoral fin.

New Providence, Bahama Is., Dr. H. C. Wood.

RHOMBOPLITES AURORUBENS, Cuv. Val. (*Centropristis*) III., 45; *Mesoprion*, Gth. I., 207; *Rhomboplites*, Gill. Proc. A. N. Sci., Phil., 1862, 237.

St. Martins, Dr. Rijgersma.

CHRYSOPHRYS CALAMUS, Cuv. Val. VI., 206; Günther I., 487.

St. Croix, Thos. Davidson.

Pristipomatidæ.

ANISOTREMUS VIRGINICUS, Linn. *Pristipoma*, Cuv. Val.; Günther I,, 288; *P. rodo*, C., V.; *Anisotremus*, Gill.; Pr. A. N. Sci., Phil., 1861, 106.

St. Croix, Capt. Thos. Davidson, Dr. R. E. Griffith.

CONODON PLUMIERI, Bloch. Günther I, 304; . *C. antillanus* C. V.

St. Kitts, Benj. H. Lightfoot.

HAEMULUM FORMOSUM, Linn, Cuv. Val. V., 230.

St. Croix, R. E. Griffith; New Providence, H. C. Wood, M. D.

HAEMULUM ELEGANS, Cuv. Val. V., 227; Gthr. Cat. B. M. I., 306.

St. Croix, Dr. R. E. Griffith.

HAEMULUM AUROLINEATUM, Cuv. Val. V., 227; Gthr. Cat. B. M., I., 316.

St. Martins, Dr. R. E. van Rijgersma.

HAEMULUM QUADRILINEATUM, Cuv. Val. V. 177; Günther I., 312.

St. Croix, R. E. Griffith.

HAEMULUM MELANURUM, Linnæus (*Perca*), fide Poey; *H. dorsale*, Poey Memorias Cuba, II., 179.

New Providence, Dr. H. C. Wood; St. Martins, Dr. R. E. van Rijgersma; St. Croix, Dr. R. E. Griffith.

HAEMULUM XANTHOPTERUM, Cuv., Val. V., 234; Günther I., 312.

Radii D X 11, 14—15; A, III, 7. Scales 6—52—11.

The specimens in the collections agree closely with the descriptions of Valenciennes and Günther. The young lack the oblique yellow bands below the lateral line. They have two indistinct longitudinal brown ones above the lateral line.

St. Croix, Capt. Thos. Davidson and R. E. Griffith, M. D.

HAEMULUM LUTEUM, Poey, Synopsis 369; Memorias II., 174.

Scales 8—59—16; Radii, D X 11, 17, A III, 8.

The specimens differ from those described by Poey, in having the spot behind the preopercular angle very indistinct, and only a part of the blue band that crosses at that point.

The eye also is 4 times in the length of the head, instead of 4.5 times, but the largest specimen is only five inches long. Nine blue longitudinal bands on a golden ground; three above, and one on the lateral line. The basis of the caudal is of a dirty shade; scarcely black as Poey describes.

St. Martins, Dr. R. E. van Rijgersma.

Scienidæ.

EQUES LANCEOLATUS, Linn. Castelnau; Günther Cat. B. M., II., 279; E. *balteatus*, Cuv. Val.

Saint Croix, Capt. Thos. Davidson; Dr. R. E. Griffith, St. Martins, Dr. Rijgersma.

EQUES ACUMINATUS, Bloch. Castelnau; Gthr. Cat. I., 280; *E. lineatus*, C. V.

St. Croix, Capt. Davidson, Dr. Griffith.

EQUES PUNCTATUS, Bloch. Cuv. Val. V., 167; Gthr. l. c.

St. Croix, Dr. Griffith.

UMBRINA BROUSSONETTII, Cuv. Val. V., 139.

Var. I. Depth 4 times in length; Radii D. XI—27; A, II, 6; scales, 5—58—10: nine vertical brown bars.

St. Martins, R. E. Rijgersma, M. D.

Var. II. Like the above, but deeper; depth 3.3-5 times in total length, and no vertical brown bars.

St. Martins, R. E. Rijgersma, M. D.

Günther gives scales of the lateral line, 48, and that the maxillary only reaches the line of the orbit which may be an error, as he describes from skins only: otherwise the species is different from that of Cuvier and Valenciennes.

CORVINA RONCHUS, Cuv. Val. V., 107; Günther Catal. II.. 299.

St. Martins, R. E. van Rijgersma, M. D.

Mullidæ.

MULLOIDES BALTEATUS, Cuv. Val. III.; *M. flavovittatus*, Poey, Mem. Cuba 224; Günther Cat. I., 403.

St. Kitts, B. H. Lightfoot; St. Martins, Dr. R. E. van Rijgersma.

UPENEUS MACULATUS, Cuv. Val. III., 478; Gthr. Catal. I., 408.

St. Croix, Dr. R. E. Griffith.

UPENEUS PUNCTATUS, Cuv. Val. III.; Gthr. Catal. I., 408.

St. Kitts, B. F. Lightfoot.

Scombridæ.

CYBIUM ACERVUM, Cuv. Val. VIII., 186; Poey, Synopsis, 373; *C. caballa* C. V., VIII., 187; Günther Catalogue II., 373.

St. Martins, Dr. R. E. van Rijgersma.

Carangidæ.

CARANX HIPPUS, Linn; Gthr. Cat. II., 449.

St. Kitts, B. H. Lightfoot: St. Croix, Capt. Thos. Davidson.

SELAR RUBER, Bloch; *Caranx blochii* Cuv. Val. IX, 69; Günther Catal. II., 430.

St. Croix, Dr. R. E. Griffith.

BLEPHARICHTHYS CRINITUS, Akerly; Gill Pr. A. Nat. Sci., Phil., 1862, 436. *Blepharis sutor*, Cuv. Val. IX., 161; Guich. Sagras Cuba 114; Günther Catal. B. M., II., 454.

St. Martins, Dr. R. E. van Rijgersma.

VOMER SETIPINNIS, Mitch; Günther Catal. II., 459; *Vomer brownii* C. Val. IX., 189, Tab 256.

St. Croix, Dr. R. E. Griffith.

TRACHYNOTUS GLAUCUS, Cuv. Val. VIII., 400; Gthr. Catal. II., 480.

St. Martins, Dr. Rijgersma; St. Croix, R. E. Griffith, M. D.

TRACHYNOTUS RHOMBOIDES, C. V. VIII., 407; Guichenot Sagras Cuba, 108; *T. ovatus var.* Günther Catal. B. M., II., 481.

St. Croix, Capt. T. Davidson.

PEMPHERIS MULLERII, Poey, Memorias, s. H. N. Cuba II., 203.

St. Martins, Dr. R. E. van Rijgersma.

Triglidæ.

SCORPAENA GRANDICORNIS, Cuv. Val. IV., 309; Günther Catal. II., 114.

St. Croix, Dr. Griffith.

DACTYLOPTERUS VOLITANS, Linn; Cuv. Val. IV., p. 114; Günther Catal. II., 221.

St. Martins, Dr. Rijgersma.

Sphyraenidæ.

SPHYRAENA BARRACUDA, Cuv. Val. III., 343, Tab. 66.

Radii D. V. I. 9, A. I. 9. Scales 10—77—15.

This specimen presents the characters by which it is said to differ from *S. picuda*, by Poey, and does not agree in many points with Günther's description of the latter. Thus the spinous dorsal commences above the distal third or fourth of the pectoral and the base of the ventral. Eye dermal 6.33 times in head; no mandibular appendage. Sides of uniform color, anal with a large black spot.

St. Martins, Dr. Rijgersma.

Rhegnopteri.

Polynemidæ.

TRICHIDIUM PLUMIERI, Lacep *Polynemus americanus*; Cuv. Val. III., 393; *P. plumieri* Gthr. Catal. II., 321; *Trichidium* Gill.

St. Martin's, Dr. Rijgersma.

Scyphobranchii.

Blenniidæ.

LABRISOMUS PECTINIFER, Cuv. Val. (*Clinus*) XI., 373; *Labrisomus* Sw. Gill; Pr. A. N. Sci., Phil., 1860, 21–105; *Clinus nuchipinnis* Guthr. Cat. II., 262.

St. Martins, Dr. R. E. Rijgersma.

LABRISOMUS BIGUTTATUS, Cope sp. nov.

Radial formula; D. XIX. I. 11; A. II, 16; the first dorsal spines the longest, last spine longer than penultimate. Length of head without opercular flap, 3.66 times in length (exclusive of caudal fin). Eye a little less than .25 length of head; .4 greater than interorbital width. Pectoral fin to fifth anal. Scales large, counted from spinous dorsal to vent; rows 4—46—10. Pale reddish brown, humerus red veined; rufous specks on anterior part of sides. Seven subquadrate brown blotches from nape to caudal fin, continued with interruptions as lateral bands; the fourth near end of spinous dorsal, black. A black spot at base of membrane between I to III dorsal spines. Two small brown spots behind orbit, the posterior on operculum. Length, 2.25 inches.

This species is well distinguished from the last by the large scales, form of dorsal fin, coloration, etc.

From New Providence, Bahamas. Dr. H. C. Wood's collection. Also a very small specimen from Dr. Rijgersma, St. Martin's.

Gobiidæ.

CULIUS PERNIGER. Cope sp. nov.

No vomerine teeth. A strong spine at the posterior angle of preoperculum, directed downwards. These characters define the genus Culius Bleeker.

Radial formula; D. VI. I. 9; A. I. 9. Lateral line 61. Head, 4.25 times in length (with caudal fin); depth of body, 4.75 times in same. Eye, vertical diameter, 3 times in interorbital width. Premaxillary spines not prominent in profile; scaling of vertex extending to their extremities. Longitudinal diameter of orbit one-sixth length of head. Length five inches.

Color black, abdomen brown, fins dusky. The first dorsal with white extremity and two longitudinal black bars, one along the base. Other fins with small black bars. Maxillary or caudal spot or ocellus.

From St. Martin's, Dr. R. E. van Rijgersma.

This species is much like the *Eleotris gyrinus*, which species is not stated to possess the preorbital armature by Cuvier and Valenciennes, and is especially omitted from the spiniferous group by Günther.*

GOBIUS SOPORATOR, Cuv. Val. XII., 56. Günther Catal III., 26.

St. Martin's, Dr. Rijgersma; New Providence, Dr. H. C. Wood.

GOBIUS BANANA, Cuv. Val. XII., 103. Günther Catal. III., 159.

St. Domingo, Wm. McGabb.

Gobiesocidæ.

GOBIESOX CERASINUS. Cope sp. nov.

Head very wide, ovate, broad as long to superior basis of pectoral fin; its length three times in the total, including caudal fin. Eye large, 3.5 times in head, diameter equal frontal width. Teeth, ten on each side of each jaw, none of the superior incisors, but the two median on each side larger than the others; three teeth on each side below horizontal, the others vertical; two only of the former, incisors; the median one on each side of these much the larger. Each horizontal tooth with a small one behind it; no canine like tooth. Profile regularly descending from supraoccipital region. A long subopercular spine. Fin radii D. VI. A. 6. C. 12. P. 24. V. 4. Dorsal beginning with the last fourth the distance between end of muzzle and basis of caudal.

Upper surfaces and fins, light crimson lake. Below whitish. No spots. Length, 2.5 inches.

* *Culius amblyopsis*, Cope sp. nov.

Radial formula; D. VI. 9; A. I. 8. Scales lat. line 46. Eye, long diameter, 5.5 times in that of head, twice in interorbital width. Preopercular spine strong, decurved. Width of head .6 its length; latter 3.4 times in total without caudal. Depth 4.25 times in same. Chin prominent; premaxillary spines forming a projection in the profile. Length three inches.

Color brown; a black spot above at bases of pectoral fin. First dorsal and anal dusky; second dorsal and caudal delicately cross-barred with blackish. Three black lines from orbit behind and below.

Surinam, Dr. Chas Hering.

This species resembles the *E. gyrinus*, but has larger scales besides the preopercular spine. Three specimens.

This species is nearest the *G. rupestris*, Poey and *G. macrophthalmus*, Gth., judging by the descriptions. From the former it differs in not having the head .25 in length, nor a suddenly descending muzzle profile, nor six teeth on each side of each jaw, nor 20 pectoral radii, and in coloration. From the latter, which it resembles in color, it differs in not having the origin of the dorsal fin, two-fifth of its distance from the snout, in not having four short incisors on each side the lower jaw, separated by a canine-like tooth from the conical lateral, etc.

From St. Martin's, W. I. Dr. R. E. van Rijgersma's collection.

Epilasmia.

Chætodontidæ.

SAROTHRODUS SEDENTARIUS, Poey Mem. II., 203. *Chætodon gracilis*, Günther. Catal. B. Mus. II., 20.
St. Martin's, Dr. R. E. van Rijgersma.
SAROTHRODUS CAPISTRATUS, Linn, Cuv. Val. (*Chætodon*) VII. 64, Günther II., 12.
St. Martin's, Dr. Rijgersma; St. Croix, Thos. Davidson and Dr. Griffith.
SAROTHRODUS BIMACULATUS, Bloch. Cuv. Val. VII., 67, Günther II., 9. (*Chætodon*).
St. Croix, Capt. Thos. Davidson, Dr. R. E. Griffith.
SAROTHRODUS STRIATUS, Linn. (*Chætodon*) Cuv. Val. VII., 10, Günther II., 8.
St. Croix, Thos. Davidson, Dr. R. E. Griffith.
HOLACANTHUS CILIARIS, Linn. (*Chætodon*). Lacepede, Cuv. Val. VII., 154, Günther II., 46.
St. Martin's, Dr. R. E. Rijgersma; St Croix, R. E. Griffith; New Providence, Dr. H. C. Wood.
HOLACANTHUS TRICOLOR, Bloch. (*Chætodon*) Cuv. Val. VII., 162, Günther II., 49.
St. Martins, Dr. Rijgersma; St. Kitts, B. H. Lightfoot; St. Croix, Capt. Davidson and Dr. Griffith.
POMACENTRUS QUINQUECINCTUS, Cuv. Val. VII., 210.
St. Kitts, B. F. Lightfoot; St. Martin's, Dr. Rijgersma; St. Croix, Dr. Griffith.

Acanthuridæ.

ACANTHURUS CHIRURGUS, Bloch. Cuv. Val. X., 168; Günther Catal. III., 329.
St. Croix, Capt. Davidson, Dr. Griffith; New Providence, Dr. H. C. Wood; St. Kitts, B. H. Lightfoot.
ACANTHURUS CŒRULEUS, Bl. Schn. Cuv. Val. X., 179; Günther Catal. 336.
St. Croix, Dr. Griffith, Capt. Davidson; New Providence, Dr. H. C. Wood.

PLECTOGNATHI.

Ostraciidæ.

OSTRACIUM QUADRICORNE, Linn., Hollard Monogr. Ostracionides Am. Sc. Nat., 1857, 148. Poey Repertoire, 1868, 439.
St. Martin's, Dr. Rijgersma; St. Croix, Capt. Davidson; New Providence, Dr. Wood.
OSTRACIUM TRIGONUM, Linn., Hollard l. c., 150.
St. Martin's, Dr. R. E. van Rijgersma.
OSTRACIUM BICAUDALE, Linn., Hollard l. c., 15; Poey l. c., 1868, 442.
St. Martin's, Dr. Rijgersma.
OSTRACIUM TRIQUETRUM, Linn., Hollard l. c., 154; Poey l. c., 442.
St. Croix, Capt. Davidson; St. Martin's Dr. Rijgersma; Vera Cruz, Dr. Burroughs; Brazil, Wm. Hyde.
OSTRACIUM EXPANSUM. Cope sp. nov.

General character of *O. bicaudale* L., that is, trigonal in section, with a horn on each side of the vent, on the the basi-lateral angle. The body is short and elevated, the dorsal line rising into a hump, and descending to the base of the caudal peduncle at an angle of 45°. On the upper side of the base of the latter, a separate bony shield exists,

as in *O. trigonum* and *O. ovinum*. The inferolateral sides also expand or flare out strongly at the middle of the length, making the abdominal width equal to the height. The horns are well developed. Superciliary ridges prominent, unarmed, interorbital region concave, front descending very steeply, slightly concave, not projecting beyond the premaxillary. Lateral scales a little higher than broad, all with a central clump and six radiating lines of sharply defined rounded tubercles. These cause a sharp serration of the dorsal ridge. Radii D. 10; C. 10; A. 10; caudal fin truncate. Total length (axial) 0m. 11; of shell without muzzle and caudal peduncle 0.m.0 75; greatest elevation of dorsal ridge (oblique) 0m. 055; greatest abdominal width 0m.050; width at supercilia 0m. 018; total length caudal peduncle and fin 0m. 042.

Color, light brown, with a pale yellowish spot or area near the middle of each plate. A short chain-like band of dark brown, enclosing yellowish gray areas, extends from below the orbit to behind the axilla; a similar but narrower parallel band, exists at a point 3–5ths the distance from the last to the dorsal fin; in one specimen it is obsolete. Upper side of the caudal fin closely yellow spotted. Fins unicolor.

Three specimens from unknown locality.

Fig. 9. Ostracium expansum, Cope.

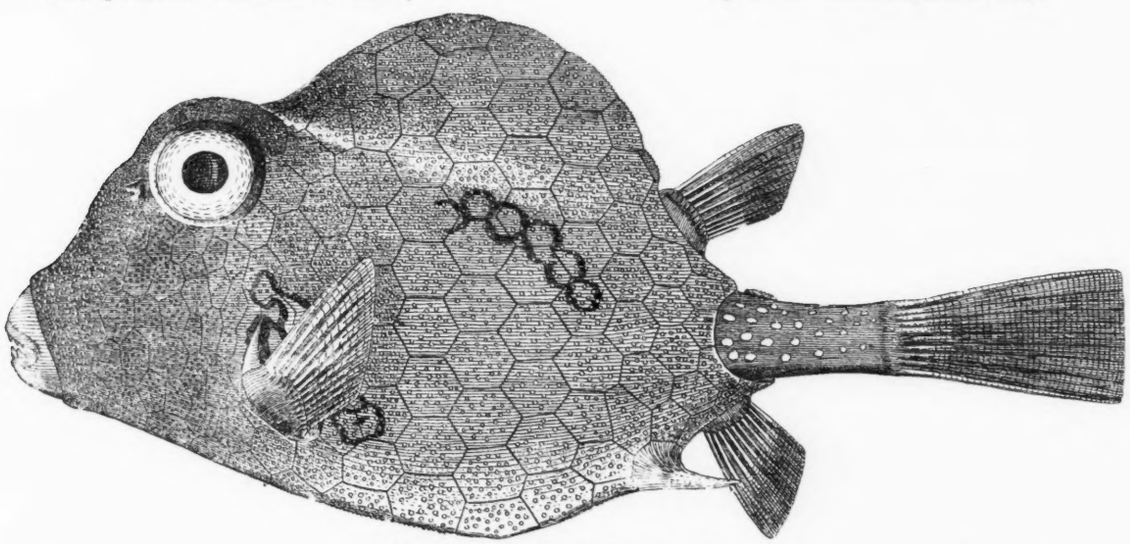

Fig. 10. Ostracium expansum, Cope.

This species has somewhat the form of *O. triquetrum*, but is shorter and with superior and lateral ridges more convex or expanded. It differs from that species and *O. bicaudale* in having no distinct scales over the operculum, and no fissure extending anterior to the latter, to permit movements of the respiratory apparatus.*

*CIBOTIUM FISSUM, Cope sp. nov.

Transverse section square, convex above, without dorsal keel or tubercle. Depth between lateral angles .75 greatest width. Interorbital region plane, profile of muzzle little concave, not projecting distally. Orbit oval 2.3-5 times in length of head, equal to length of muzzle that is boxed, and equal to the length of the opercular slit. Scales with rugose radii, those beneath the orbit excavated. Length of head (to superior end of opercular slit) 4.66 times to end of caudal fin. Radii D. 9; C 10; A. 9. Color above and laterally brown, below yellow. The sides closely marked with round blackish spots in regular quincunx, parts of three on each scale. Belly with a larger brown spot in the centre of each scale. Front and sides and end of dorsal shield with small black spots; caudal peduncle and fin brown, with black spots; other fins immaculate. Total length 0m.118; of shell 0m.077; width above posteriorly 0m.01; interorbital width 0m'019; greatest dorsal width 0m.034.

Habitat unknown, probably the Indian or Pacific Ocean.

The affinities of this species are to *C. cubicum*, which differs according to Bleeker in its more concave profile, and large ring-shaped spots. As compared with *O. punctatum*, it has a shorter muzzle and longer opercular slit (whence the name) the latter entering the former in that species 2.5 times instead of once.

Balistidæ.

ALEUTERES PICTURATUS, Poey Proc. Ac. Nat. Sci. Phila., 1863, 183; Repertorio, Cuba, 1868, 438.

New Providence, Bahamas, Dr. H. C. Wood. A specimen of 0m.548 in length. Radii D. 47; A. 48. St. Martins, Dr. Rijgersma.

MONACANTHUS MACROCERUS, Hollard Ami. Sci. Nat. (4) II., 327; tab. 12 fig., 1. Poey Conspectus.

St. Martins, Dr. R. E. van Rijgersma.

MONACANTHUS IRRORATUS, Poey Memorias s. H. Nat., Cuba II., 330.

St. Croix, Dr. R. E. Griffith; St. Martins, Dr. Rijgersma.

MONACANTHUS TOMENTOSUS, Linnè (*Balistes*) Hollard l. c., 348; Tab., 13 f. 1.

St. Martins, Dr. R. E. van Rijgersma.

MONACANTHUS DAVIDSONII, Cope sp. nov.

Char. Allied to *M. villosus*, Ehrbg. Scales with three acute spines on a common but low base; no ventral fan; some large spines directed posteriorly on the caudal peduncle. Dorsal spine with strong teeth. Slender filaments scattered distantly over the sides. Striped.

Description. Spine of first dorsal fin one-half the depth of the body. Radii, 2 D. 30; A. 28. Pelvic plate elongate, spinous all round; abdominal margin strongly convex in front of vent, the posterior outline vertical. Spines of most of the caudal peduncle villiform, among them, six spines in two clusters of three each, one above and one below the median line. They are slender, with tips a very little recurved. Diameter of orbit about one-third length of muzzle.

The floating processes are filiform, and not subdivided; their length about equals the diameter of the eye.

Color brown, with five longitudinal brown bands with pale centres. The superior and inferior form three dark blotches at the base of each soft ray or fin. The anterior parts of the dots marked with numerous black dots. Head immaculate; caudal fin with a median brown cross-band. Depth at vent 2.2 times in length without caudal; depth at middle orbit 2.4 times in same. Length four inches.

This species is near the *M. villosus*, Ehrb., in the filamentous processes, and number of dorsal radii, but differs much in the more elongate form, the caudal spines, the scale spines and the coloration.

Habitat, the Florida Reef. Obtained by George Davidson of U. S. Coast Survey. This gentleman has devoted spare moments and favorable opportunities, found during the performance of his duties, to the pursuit of Natural History, and has enriched the museums of Philadelphia with many valuable objects. This species is dedicated to him.

MONACANTHUS SPILONOTUS, Cope sp. nov.

Char. Scales supporting a pedicle whose summit divides into four or five radiating spines. Dorsal spine long, with simple teeth behind. Brown with darker dorsal spot and streaks.

Descr. No brush or spines on the caudal peduncle. Dorsal and anal fins elevated medially, descending posteriorly rather abruptly; radii respectively, 32, 31–2. General form elongate. Depth at vent 2.5 times in length, exclusive of caudal fin; length or dorsal spine 4.25 in same; diameter of orbit not quite 3 times in length of muzzle. Pelvic shield narrow, posterior movable portion present; spines all round. Outline of front straight. Length three inches.

Color light brown, some longitudinal lines just below the dorsal fin, the median developing a dark spot below the middle of the soft dorsal.

Three specimens from the Gulf of Mexico, obtained by Capt. Baker.

The structure of the scales reminds one of that of the *M. tricuspis* of Hollard, but there are but three points on those of the latter ; it has also strong spines on the caudal peduncle, which are wanting here.*

MONACANTHUS AMPHIOXYS, Cope sp. nov.

Scales with a single spine ; no larger spines or brush on the caudal peduncle. Radii D. 35 ; A. 30. Dorsal spines anteriorly with two rows of small spinules directed downward, and a single median series directed upward, near the base on each spine of the lateral series, is a short branch-spine directed upward. A very weak series of spines extends down each side of the posterior face. The directions of the anterior and posterior rays of the second dorsal are convergent. The pelvic plate is short, without movable portion, with two spines directed forward, two backward and three on each side upwards. The orbit is contained three times in the length of the muzzle in an individual of two inches long. No preanal expansion. Anal depth 2.5 times in length without caudal fin ; length to upper opercular slit 2.66 in same ; depth at pelvic plate, one-half same. Dorsal and anal membranes not perforate at base.

Color, uniform leaden.

St. Martins, Dr. R. E. van Rijgersma.

This species appears distinct from those described. Poey, Repertorio, 1868, 437, mentions a species *M. punctatus*, of which I can find no full description. He enumerates its differences from *M. irroratus*, Poey, and as he does not include those of the scales and dorsal spine, the present is probably a different fish. In the dorsal spine it is especially different from the *M. irroratus* and all other species I have seen.

*MONACANTHUS SANDVICENSIS, Q. G. Voyage d'l Uranie Zoologie, 1824, p. 214.

This is another species allied to the *M. granulatus*, but without the barbs which arm the posterior face of the dorsal spine in that fish, and with a larger number of fin radii.

Scales with a single simple spine, no larger spines or brush on the caudal peduncle. Pelvic bone broad ovate, with remarkably small spines on its circumference. Dorsal spine very long, its length 4.5 times in length without caudal, its base over the middle of the orbit. A series of short weak spines on the sides of the basal third of the dorsal spine ; anteriorly several rows of small asperities. Radii D. 36 ; A. 31 ; the anterior part of both fins much elevated, the rays of the posterior portion rapidly shortening and directed forward. Front slightly convex ; upper teeth projecting beyond mandible. Orbit three times in muzzle to edge of lip. Anal depth 2.33 times in depth to origin of caudal ; pelvic depth 1.66 in same. Line from pelvic plate to vent, straight, acute. Length four inches. Color uniform brown.

From the Sandwich Islands. Discovered by Jno. K. Townsend.

MONACANTHUS HOMOPTERUS, Cope sp. nov.

This species is near the last in the characters of the scales, pelvic bone (which has, however, stronger spines anteriorly and posteriorly) the character of the dorsal spine, the number of fin rays (D. 25 ; A. 30), and the general proportions. It differs as follows: The rugosities on the sides and front of the dorsal spine are in close contact, and not separated by smooth spaces as in *M. sandvicensis*. The radii of the second dorsal and anal are subparallel and subequal, the anterior rays lacking the prolongation seen in many species, and the posterior not being anteriorly directed as in the last. Orbit four times in muzzle. Depth at vent 2.4 times in length without caudal ; at pelvic bone a little more than one half. Fin membranes not perforate.

Color light brown ; fins very light. Length 2.5 inches.

Locality said to be Australia ; from Wm. Wood.

MONACANTHUS HYPARGYREUS, Cope. sp nov.

Scales with a single, simple spine. Radii D. 34 ; A 33 ; the membrane perforate at the base. Dorsal and anal fins elevated anteriorly (at 6 and 7 ray), and gradually descending posteriorly as in some Carangoids, the radii all direc ed posteriorly, the inter radial membranes perforated at the bases. Pelvic plate small, with a few spines. Depth at vent 3.6 times in length, exclusive of caudal fin. The form is hence elongate, the profile nearly straight, the lower jaw a little longer. Diameter of orbit one-half the length of the muzzle. Dorsal spine above middle of orbit without spines posteriorly, with two rows in front and one on each side. Length three and a half inches.

The superior half of the body is light rufous in spirits, the inferior half silvery white.

Two specimens supposed to be from Australia ; from Wm. Wood.

This species is of the type of *M. vittatus*, Sol.. and *M. paragaudatus*, Rich. It is nearer the former, which, according to Steindachner,* has a smaller orbit (¼th head), four lateral bands and fewer fin radii. The posterior limb of the orbit falls above the opercular slit, in *M. hypargyreus* behind it.

*Sitzsungberichte Wien. Academie, March, 1866.

BALISTES VETULUS, Linn., Hollard Ann. Sci. Nat., 1854, 305. Poey Repertorio, 1868, 434.
St. Martins, Dr. Rijgersma; St. Croix, R. E. Griffith, M. D.; St. Kitts, B. H. Lightfoot.

BALISTES PICEUS, Poey, Proc. Acad. Nat. Sci., Phila., 1863, p. 180.
St. Croix, R. E. Griffith, M. D.

BALISTES MORIBUNDUS, Cope sp. nov.

This species belongs to the section of the genus with shields above the axilla, but whether to any of Hollard's subsections seems doubtful. The scales are furnished with two rows of delicate spines, several in an anterior curved row, and two in a posterior. Thus the characters are like those of some of the bristly *Monacanthi*. The form is elevated, and the third dorsal spine is long; there are no spines on the caudal peduncle.

Radii, D. 29; A. 26: none of those of either fin prolonged. Caudal regularly convex. Dorsal spine bristly in front. Pelvic bone elongate, spinous behind. Pelvic depth twice, humeral depth 2.25 times in total length. Diameter of orbit twice in muzzle. Anterior teeth acuminate. Cheek-scales numerous rugose, no naked fissures. Profile nearly straight. Length of dorsal spine 1.5 times orbit. Eight rather long post-pelvic radii.

Color brown, with many blue spots all over the sides of the head and body, the pelvic and gular regions unicolor. Three black spots at the base of the second dorsal fin, one at the base of the first. Length 2.5 inches.

St. Martins, Dr. R. E. van Rijgersma.

BALISTES ASPERRIMUS, Cope sp. nov.

Division I. A. of the genus, of Hollard; that is, the scapular squamation similar to that of the sides, and the third dorsal spine well developed; the cheek-scales not separated by naked fissures.

The scales possess a convex vertical series of short acute spines, with a median large spine directed backward from the middle of the series. Its anterior margin is sharp, and its anterior base supported by a number of convergent ribs. The spines of the dorsal scales have a branch-scale at the base in front. The cheek-scales are very numerous and not larger than those of the body. Radii D. 26; A. 24. Orbit large 2.25 times in muzzle, four times in head. Dorsal spine long, stout, with four rows of spinules, smooth behind. No larger caudal spines. Caudal fin convex, without projecting angles.

Pelvic depth 1.8, humeral 2.2 times in total length; anal depth 2.4 times in the same. Length three inches. Profile nearly straight, interrupted by the convex orbital margin.

Color, brown above, yellowish below. Four longitudinal dark brown stripes above the middle of the side, which break into spots posteriorly. Three brown spots at base of dorsal fin. Belly with broad irregular dark bands; on the caudal peduncle and pelvic region similar broad bands form a coarse reticulated pattern. Fins brown spotted.

Locality uncertain, but probably St. Martins, W. I.

This species is quite distant from its allies *B. macrops* and *B. sobaco*, of Poey.

BALISTES MELANOPTERUS, Cope sp. nov.

Nearly related to the last, and of the same section of the genus. Its characteristic differences from *B. asperrimus* are seen in the scales, which are only spiniferous on the posterior middle of the side, and on the caudal peduncle, instead of being so over the whole body; in the first dorsal ray which is rugose, not spiniferous; in the increased number of dorsal and anal radii, in the interorbital region, which is convex in cross section, not concave; and finally in color.

Radii 2 D. 24; A. 21. Anterior rays much larger than posterior, but not produced beyond the membrane. Extremity of caudal fin slightly rounded. First spinous dorsal ray as long as from orbit to rictus oris, rugose, the rugæ almost spinous distally, the points all directed forward, not outward as in B. asperrimus. Third spine well developed. Scales with three rows of spines on the posterior, and four on the anterior part of the body. On the former, one anterior is prominent and directed backward, some ten rows being most marked; they disappear toward other parts of the body, and the smaller spines become tubercles. The whole surface of the scale is covered with these, and the

radiating ridges which converge towards them. The scales on the scapular region are very small. Pelvic plate, narrow, without joint, cheek-scales in transverse series. Post-pelvic rays indistinct or wanting.

Diameter of orbit twice in muzzle and teeth; front convex in profile, head rather acuminate; anal depth 2.66 times in same. Length of head (to branchial slit) 3.33 in the same. Length four inches.

Color blackish above, brown below, spotted except on the head and anteror part of the back with pale brown spots smaller than the pupil. Unpaired fins uniform black.

From Darien; collected by J. Petigru Carson of the Darien Expedition.

BALISTES SOBACUS, Poey, Memorias II., 324; Repertorio h. n., Cuba, 1868, 434.

St. Martins, Dr. Rijgersma; large specimen.

XANTHICHTHYS CICATRICOSUS, Poey (*Balistes*) Memorias s. n. H., Cuba, II., 327. Repertorio s. h. n., Cuba, 1868, 435.

St. Martins, Dr. R. E. van Rijgersma; St. Croix, Dr. R. E Griffith.

Tetrodontidæ.

CANTHOGASTER CAUDICINCTUS, Richardson voyage Herald, 1854, 162, Tab. XXX. fig. 1, 2, 3. *Tetraodon ornatus*, Poey, Repertorio h. n., Cuba, 1808, II. 244.

St. Martins, Dr. R. E. van Rijgersma.

TETRODON RETICULARIS, Kaup voyage Herald, 1854, 161, Tab. XXXI.

St. Martins, Dr. Rijgersma.

TETRODON SPENGLERII, Günth., Cat. B. M. VIII.

Belly spinous to vent, back in a small patch from the occiput to above the tips of the ventral fins. Radii D. 9; A. 7. Head 3.25 in total length, eye 4.5 in head, 2.5 times in muzzle. Short (white) dermal processes on the sides of the body, and posterior part of the head. Tips very papillose within. Muzzle narrow, straight, gently descending in profile; width of frontal bone only .6 of eyes diameter. Dorsal and anal fins opposite; the body at that point as wide as or wider than deep. Caudal fin rounded. Length, 4.5 and 5 inches.

Color reddish dark gray above, with a few transverse interrupted dorsal shades; the sides clouded with faint brown spots. A straw yellow band from the chin through the axilla to base of tail, bounded below by a series of about twelve strong brown spots. Caudal fin with a white ring at base, then a transverse brown band, then an equally broad yellow one; the end for the same width, brown. Belly, yellowish white.

St. Martins, W. I., Dr. Rijgersma; New Providence, Dr. Wood; Tortugas, Jas. Roosevelt.

This is probably the *T. lagocephalus* of some others, but it is not the fish described under that name by Bloch. The latter has a smooth dorsal region like the *T. lævigatus*, no dermal appendages, and a spotter belly, besides other characters it is much more like the *T. spengleri* of Bloch, but that species has a more extensive patch of dorsal spines, and a caudal fin of uniform color, besides presenting other *generic* characters. According to Bloch it comes from the East Indies.*

*TETRODON FLOREALIS, Cope sp. nov.

Belly to vent, and anterior part of sides with strong distant bristles. back to end of pectoral fin and head above to nares, with distant weaker bristles. No dermal appendages. A groove from the orbit to the tail on each side of the back, which are nearly connected by a medially interrupted cross-groove at the occipital crest. A groove concentric with and within the superciliary margin extending to the preocular region and returning, but sending also a curved branch round the front of each nostril. Eye, 4.25 times in head, 2.75 times in muzzle; head, 3.66 times in total length. Anal fin behind dorsal, both subfalcate narrow, rays D. 8; A. 7. Caudal long, truncate or slightly concave. Interorbital region concave, profile regularly descending. Length, five inches. Below immaculate white, a yellowish band on the sides; above reddish brown. ground reduced to narrow lines by the innumerable small light (? white) spots with a ring of smaller spots around each, over the upper regions of the head and body. Caudal fin delicately cross-barred; other fins unicolored.

Two specimens from the Sandwich Islands, obtained by J. K. Townsend twenty years ago. This species is allied to the *T. caboplumbeus* Richn., but differs in the fewer fin rays, as well as the color.

AROTHRON OPHRYAS, Cope sp. nov.

Form elongate, the head one-third the length to the base of the caudal fin; distance from basis 1st dorsal ray to caudal fin, 3¼ times in length from caudal. Jaws nearly equal, eyebrows prominent front concave, profile of muzzle horizontal. Eye entering six and three-

Diodontidæ.

DIODON ATINGA, Linn., Poey Repertorio, Cuba, 1868.
St. Martins Dr. Rijgersma; New Providence, Dr. Wood; Tortugas, Mr. Roosevelt.
Var. with spotted abdomen, from Panama, Dr. Ruschenberger.
DIODON HYSTRIX, Linn., *Paradiodon* Bleek., Poey Repertorio, Cuba, 1868.
St. Domingo, Edw. L. Clark.
CHILOMYCTERUS GEOMETRICUS, Bl. Poey Repertorio, Cuba, 1868.
Tortugas, Jas. Roosevelt.

HETEROSOMATA.

Pleuronectidæ.

RHOMBOIDICHTHYS LUNATUS, Linn., Günther Catal., IV., 433. *Rhombus argus.* Cuv. Regne Animal.
St. Croix, Capt. Davidson, Dr. Griffith; St. Martins, Dr. Rijgersma.

PEDICULATI.

Antennariidæ.

ANTENNARIUS MARMORATUS, Lesson, Bloch. Cuv. Val. XII., 397; Günther Catal. III., 185.
St. Martins, Dr. Rijgersma.
ANTENNARIUS MULTIOCELLATUS, Cuv. XII., 420. Günther Catal. III., 194.
St. Martins, Dr. Rijgersma; St. Croix, Capt. Davidson.

Lophiidæ.

MALTHE VESPERTILIO, Linn., Cuv. Val. XII., 440. Günther Catal. III., 200.
St. Martins, Dr. Rijgersma.

LOPHOBRANCHII.

Syngnathidæ.

SYNGNATHUS, sp.
St. Martins, Dr. Rijgersma.
HIPPOCAMPUS GUTTULATUS, Cuv.
St. Martins, Dr. Rijgersma.

HEMIBRANCHII.

Fistulariidæ.

AULOSTOMA COLORATUM, Müll. Trosch. Schomb. Hist., Barbadoes, 673. Günther Catal. B. M., III., 536.
St. Croix, Dr. Griffith, Capt. Davidson.

PERCESOCES.

Atherinidæ.

ATHERINA STIPES, Müller and Troschel in Schomb. Hist., Barb., 671. Günther Catal. B. M., III., 400.
St. Martins, Dr. Rijgersma.

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quarters times the length of the head, and 3.2 times the median interorbital space. Olfactory tentacles separated to base. Dorsal and anal fins with contracted bases, higher than long; rays D. 10; A. 10, P. 16. Spines generally short, longest on the belly, a very few between orbit and operculum. The dorsal spines commence between the posterior margin of the orbits, and extend above the basis of the pectoral; the laterals, to the anterior line of the anal, except in a band from the pectoral where they seem to be wanting; caudal peduncle chin and throat smooth. Length 0m.38, (15 inches) depth at operculum 0m·07.

Color, everywhere except on the belly, blackish, paler at base of caudal; belly yellow (white). Numerous small (.002m.) ? yellow spots everywhere, arranged more or less in lines or in quincunx. They are more numerous posteriorly and on the lower regions. They are also larger below, and vanish in the pale line of the belly. Caudal fin yellow (white) spotted, other unpaired fins uniform brown; pectoral pale, very dark at base.

This fine species was brought from the Navigator Islands, in the Pacific, by Dr. H. C. Caldwell. Its affinities are evidently to such species as *A. kappa*, Russell, and *A. meleagris*, Richdn., but its slight spinous development and color, distinguish it from the numerous species of the genus now known.

Mugilidæ.

MUGIL BRASILIENSIS, Agassiz Spix. Pisc., Brazil, p. 234, fide Günther Catal. III., 431.

St. Croix, Capt. Davidson; New Providence, Dr. H. C. Wood.

SYNENTOGNATHI.

Scombresocidæ.

EXOCOETUS AFFINIS,* Günther Catalogue British Mus., VI., 288.

St. Martins, Dr. H. E. van Rijgersma.

CYPSILURUS HILLIANUS, Gosse. Nat. Soj., Jamaica, p. 11; Poey, Memorias, Cuba, II., 301; Günther Catal. B. M., VI., 284.

St. Martins, Dr. H. E. van Rijgersma.

HEMIRHAMPHUS UNIFASCIATUS, Ranzani, *H. richardi*, Cuv. Val. XIX., 26. *Hemirhamphus unifasciatus*, Günther Catalogue VI., 262.

St. Martins, Dr. van Rijgersma. Saml. Powell obtained a specimen of this fish at Newport, R. I. I cannot find that it has been previously recorded from the coasts of the United States.

HEMIRHAMPHUS PLEII, Cuv. Val. XIX., 21.

St. Kitts, B. H. Lightfoot; St. Croix, Capt. Davidson, Dr. Griffith.

BELONE DIPLOTAENIA, Cope sp. nov.

Anterior dorsal and anal radii elongate, median and posterior dorsal radii equal. Caudal peduncle very much depressed, wider than deep, but without any keel or trace of one. No teeth on the palate.

Jaws equal, not mentioning the elongate mandibular dermal process. Length of head 2.66 times in length to base of inferior caudal border. Diameter of orbit just equal to interorbital width, and 2.5 times into postorbital space. Pectoral fin equal same space. Top of cranium nearly smooth, groove interorbital only, shallow, with median ridge. Maxillary bone concealed by preorbital, except an anterior terminal lobe. Form of body cylindric. Fin radii D. 16; A. 17; dorsal commencing above fourth anal ray. Caudal fin moderately emarginate. Total length 0m.35. From end muzzle to rictus oris 0m.062; to opercular border 0m.101; ventral fin 0m.176; anal 0m.22; lower basis caudal 0m.275. Twenty-three rows of scales between dorsal and anal fins.

Color in spirits; above brownish (probably green in life), below silver white, a blue band extends from the opercular angle to near the origin of the caudal fin. This is on the median, part of its length black edged below, and then yellow margined throughout its entire length below the black, and for a width equal to itself, i. e. 1.5 rows of scales.

St. Martins, Dr. R. E. van Rijgersma.

This species is one of the most elegant of the genus, and differs from the others already known from West Indian seas. Neither the works of Poey, Valenciennes, nor Günther contain the present one. Its maxillary bone, concealed for most of its length, and emarginate caudal fin separates it from the species allied to *B. truncata*. In *B. galeatus* C. V the head is much shorter, entering the length 3.5 times.

BELONE MACULATA, Poey Memorias, Cuba, II., 290.

St. Kitts, B. H. Lightfoot.

BELONE CARIBBAEA, Lesueur Journ. Ac. N. Sci., II., 127, C. V., 430; Günther, VI., 241.

Loc?

**Exocoetus scylla*, Cope sp. nov.

Ventral fins extending nearly to end of anal; pectorals extending to a little beyond the same point, uniformly colored. Orbit not quite equal to muzzle, 3.6 times in length of head, and .66 times in the flat interorbital space. Teeth very minute. Scales; l. l. 59, eight rows from it to dorsal fin, and 27 scales in front of latter. Fin rays D. XI; A. 11. Head one-fifth of total length (with caudal). Origin of ventral half way between margin of operculum and inferior basis of lower caudal lobe origins of dorsal and anal opposite. Color yellowish silvery: fins white, except part of edge of pectoral, which is dusky.

Total length 0m.255; to upper base of pectoral 0m.05; to basis ventral 0m.117; to basis anal 0m.148. Depth of body 0m.034, in front o ventrals. From the Coast of the Gulf of Mexico, said to be near Tobasco, Mexico. Discovered by Dr. Berendt.

Near the *E. californicus* of Cooper.

ENCHELYCEPHALI.

Congridæ.

CHILORHINUS SVENSONII, Lütken Vid. Med. Forel. Kjobenhavn, 1851, No. 1, Günther Catal. B. M., VIII., 51.

Char. gen. Fam. Congridæ; sub-fam. *Myriformes* (Bleeker). No pectoral fins; no vomerine teeth. Anterior nostrils concealed beneath the lip near the orbit; posterior (anterior in position), not tubular, but apparently in the edge of the upper lip on each side the muzzle. Caudal fin continuous.

This genus appears to be nearest the *Muraenichthys* of Bleeker, especially in the lack of pectoral fins: it differs from it in the inferior position and more tubular character of the nares of the muzzle, and in the absence of vomerine teeth.

Char. specif. The anus measures the anterior two fifths of the length, and the anal fin commences immediately behind it. The dorsal fin commences at a point half way between the vent and the end of the muzzle. The fins are narrow. The body is compressed throughout, the muzzle depressed. The form is stout, the depth entering the length only nine times. Eye entering interorbital width 2.5 times; latter equaling length of muzzle. Two series of shortly conic teeth on the palatines (Cuv. maxillaries meckel), and ten in two transverse rows on the premaxillary nasals. Three series on the dentary near the symphysis to elongate teeth. Length m.0.08. Color, uniform dark brown; throat paler; fins darker margined.*

From Id. St. Croix, West Indies, Capt. Thos. Davidson Coll.

PISOÖDONTOPHIS LATIMACULATUS, Poey Mem.

St. Martins, Dr. Rijgersma.

Anguillidæ.

ANGUILLA BOSTONIENSIS, Leseuer Journ. A. N. Sci., Phila.

St. Martins, Dr. Rijgersma.

COLOCEPHALI. †

ECHIDNA CATENATA, Bloch.; *Poecilophis catenatus*, Kaup; E. *flavofasciata*, Poey Repertorio Fis. Cuba, II., 264 (*fide* Günther).

St. Martins, Dr. Rijgersma.

GYMNOTHORAX MILIARIS, Kaup. Catalogue Brit. Mus., 90.

St. Martins, Dr. Rijgersma.

* *Ophichthys stenopterus*, Cope sp. nov.

Tail nearly twice the length of the head and body. Front convex longitudinally and transversely. Palatine and mandibular teeth in two rows, the former throughout their length. Vomerine teeth in two series, here and there in three. Eye twice in muzzle. Length of pectoral fin five times in length of head, dorsal commencing above at point 1½ length of the fin behind its extremity. Dorsal and anal fins very low; both at their anterior portions a mere fold. Length m.0.32; of head (to branchial slit) m.0.025. Superior half the body brown, inferior white. Anal and dorsal fins white. Two specimens from Japan, presented to the Mus. Academy Nat. Sciences, by Dr. A. A. Henderson.

This is one of the slender species of the genus, and is near the *O. lumbricoides* of Bleeker. It differs in the more numerous palatine teeth, more posterior origin of dorsal fin, and very much less elevated dorsal and anal fins, not having more than half the extent figured by Bleeker in his Atlas Tab. XLVIII., fig. 3.

† *Holopterura plumbea*, Cope gen. et. sp. nov.

Char. Gen. Anterior nostrils (posterior in position) concealed within the lip in front of the eye; posterior nostrils tubular, deflected and posterior to the apex of the muzzle. Branchial slits approximated below the small pectoral fins. Extremity of tail finned. Vomerine teeth present; no canines.

This is *Sphagebranchus* with caudal fin.

Char. specif. Tail 1.5 times the length of head and body. Dorsal fin commencing two lengths of the head behind muzzle. Profile, flat, muzzle narrow; interorbital space less than muzzle, equal twice diameter of orbit. Mandibulars and vomerines, two rowed in front, one-rowed behind; palatines two-rowed throughout. Total length 0m.227; of head 0m.025. Color brown above, leaden below.

West Africa, Dr. Goheen.

GYMNOTHORAX ROSTRATUS.

St. Martins, Dr. Rijgersma; St. Kitts, B. H. Lightfoot; New Providence and Bahamas, H. C. Wood, M. D.

GYMNOTHORAX NIGROCASTANEUS, Cope spec. nov.

Dorsal fin commencing above a point three lengths of the gape behind the end of the muzzle. Anterior part of head much attenuated; mandible longer than muzzle; orbit horizontally oval, its diameter entering the muzzle twice, and the interorbital width once. Posterior nostrils a long and open slit equal two-thirds the diameter of the eye, commencing on a line with its anterior margin. Anterior nareal tubes behind the end of the muzzle, short. A single row of ten small teeth on the posterior part of the vomer; then three widely spaced elongate teeth on the front, and an arched series of six teeth on the outer margin of the naso-premaxillary. Two series of maxillo-palatines, the outer smaller, mingled with still smaller, the inner larger, and freely articulated three in front and four behind. Mandibular teeth one-rowed, four spaced long ones in front, twenty-five shorter, closely set acute ones behind.

Color dark chestnut, without markings. Top of head and borders of dorsal and caudal fins black. Length 0m.65; to branchial slit 0m.077; to vent 0m.36.

St. Martins, Dr. R. E. van Rijgersma.

This eel appears to be allied to the *G. infernalis* and *G. erebus* of Poey, but the dorsal fin commences at a point much posterior to that seen in those species, and there are fewer teeth. I only know the latter from Dr. Poey's description.

ISOSPONDYLI.

Clupeidæ.

CLUPEA MACROPHTHALMA, Ranzani. Günther Catal. Brit. Mus. VIII. 421.
New Providence, Dr. Wood.

CLUPEA HUMERALIS, Cuv. Val. XX. 293. Günth. Cat. B. M. VII. 422.
St. Croix, Capt. Davidson; St. Croix, Dr. Griffith.

ELASMOBRANCHI.

SQUALI.

Scylliidæ.

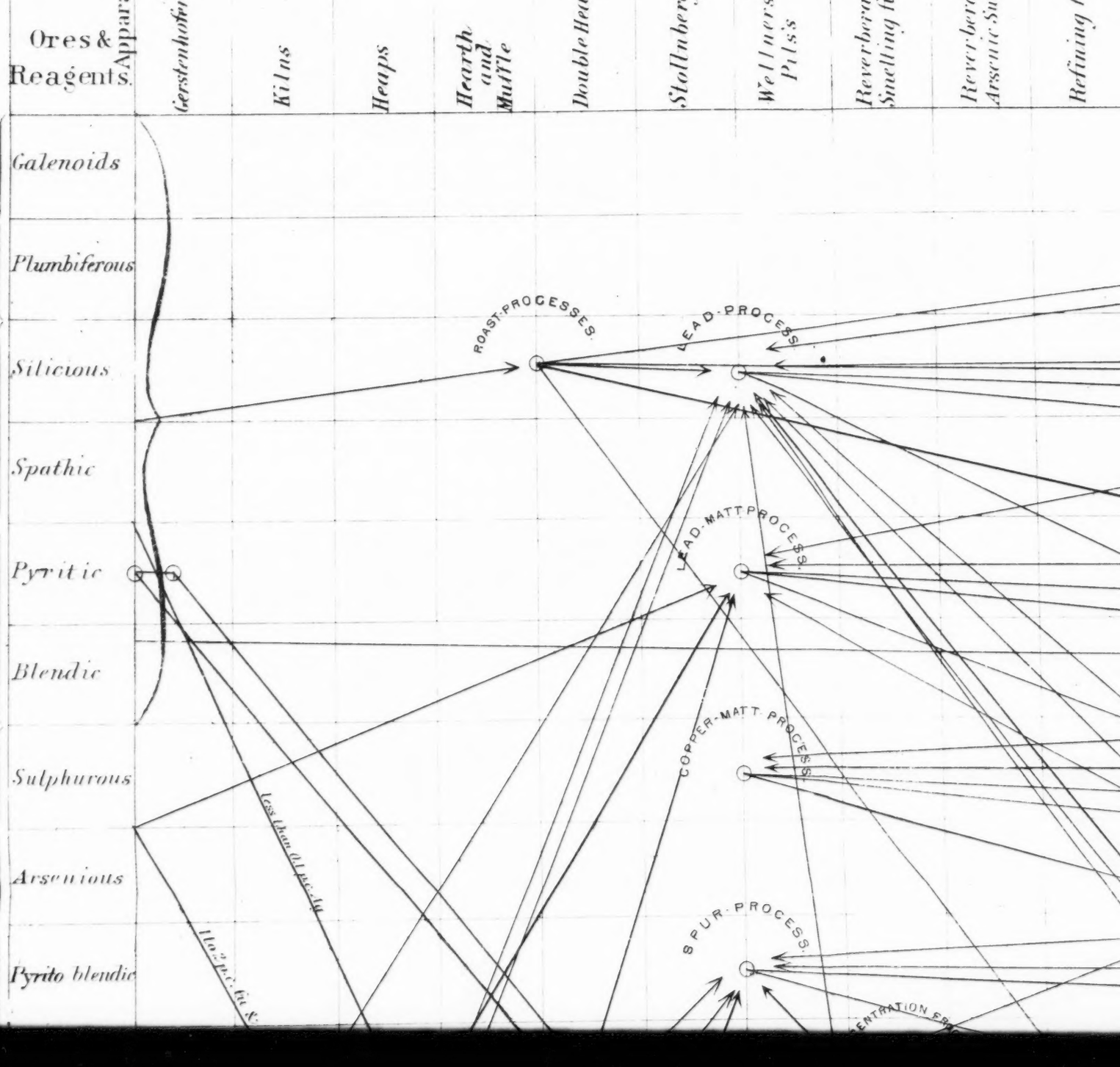
GINGLYMOSTOMA FULVUM, Poey, Memorias, II. 342. Tab. 19. f. 15. Repertorio, 1868, 455.
St. Martins, Dr. Rijgersma.

GINGLYMOSTOMA CIRRATUM, Gmelin. *S. punctatus*, Parra. *S. argus*, Bancr.
St. Martins, Dr. Rijgersma.

CHART of the FREIB

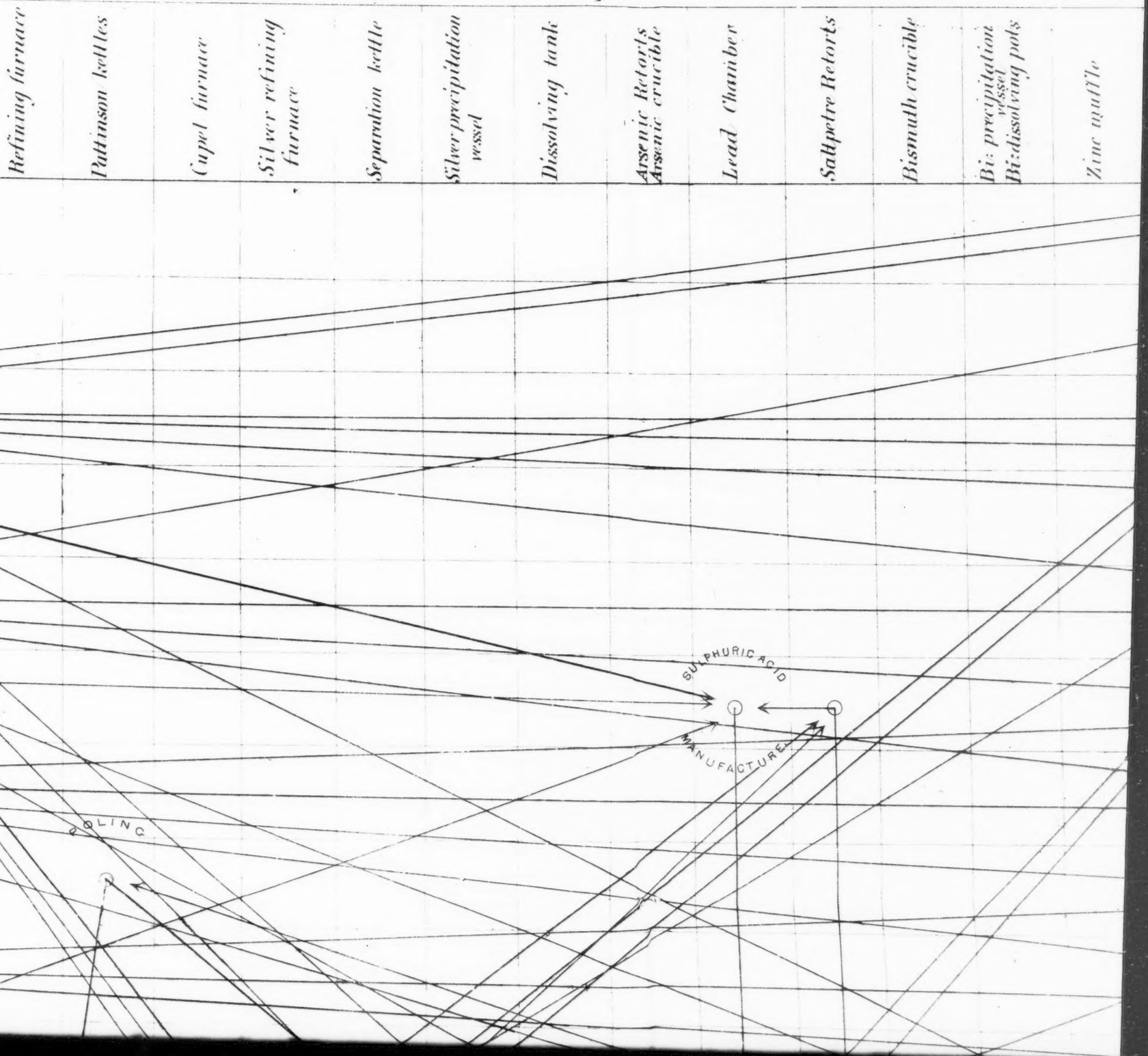
Designed & exec

Read before the American I



BERG SMELTING PROCESSE

executed by Persifor Frazer, Jr., of Philadelphia.
an Philosophical Society at Philadelphia, June 17th 1870.



ART of the FREIBERG SMELTI

Designed & executed by Persifor Frazer, Jr., of Phi

Read before the American Philosophical Society at Phila

Hearth and Muffle

Double Hearth

Stollnberg

Wellners Plisis

Reverberatory Smelting furnace

Reverberatory Arsenic Sublimimg

Refining furnace

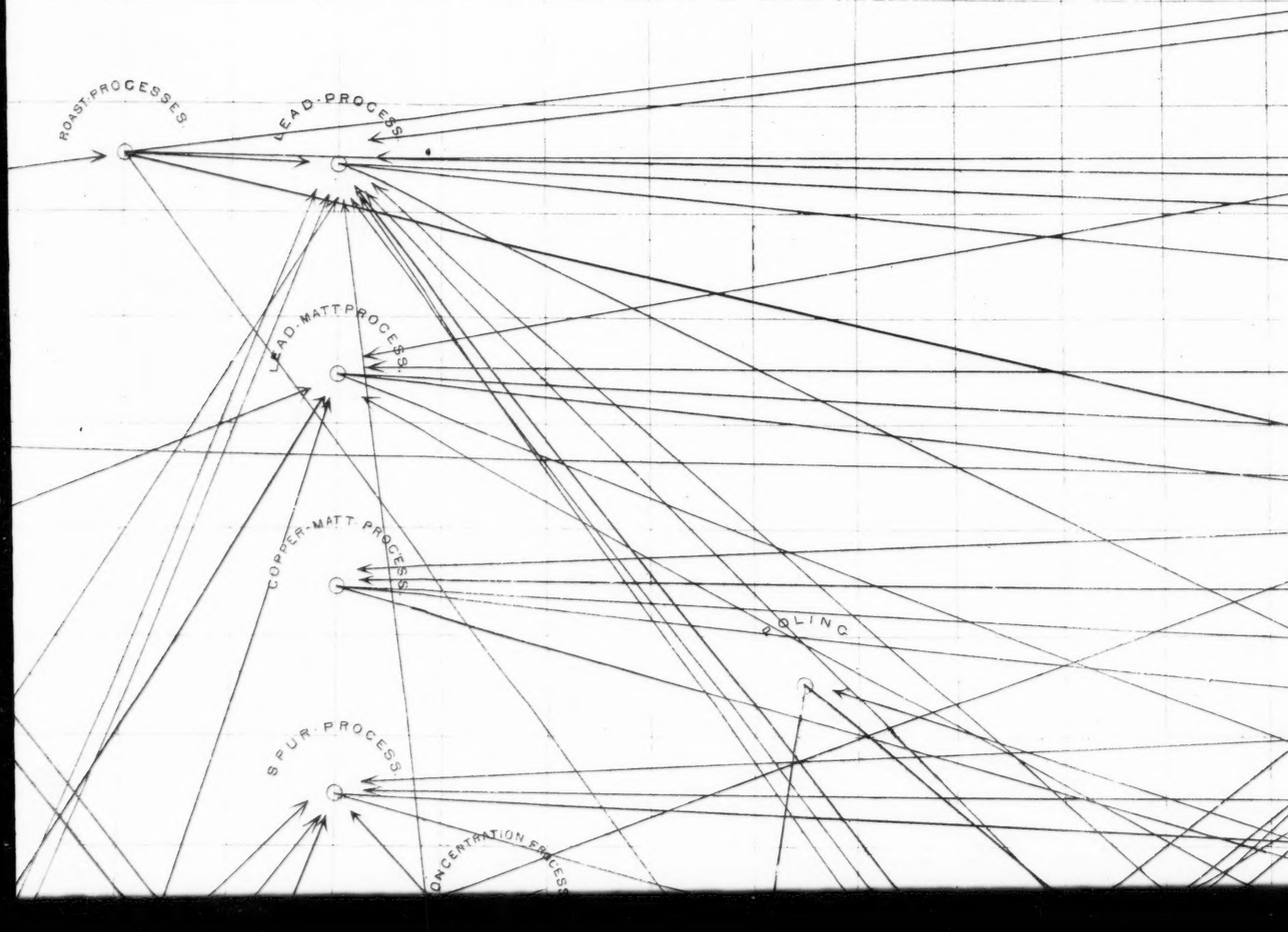
Pattinson kettles

Cupel furnace

Silver refining furnace

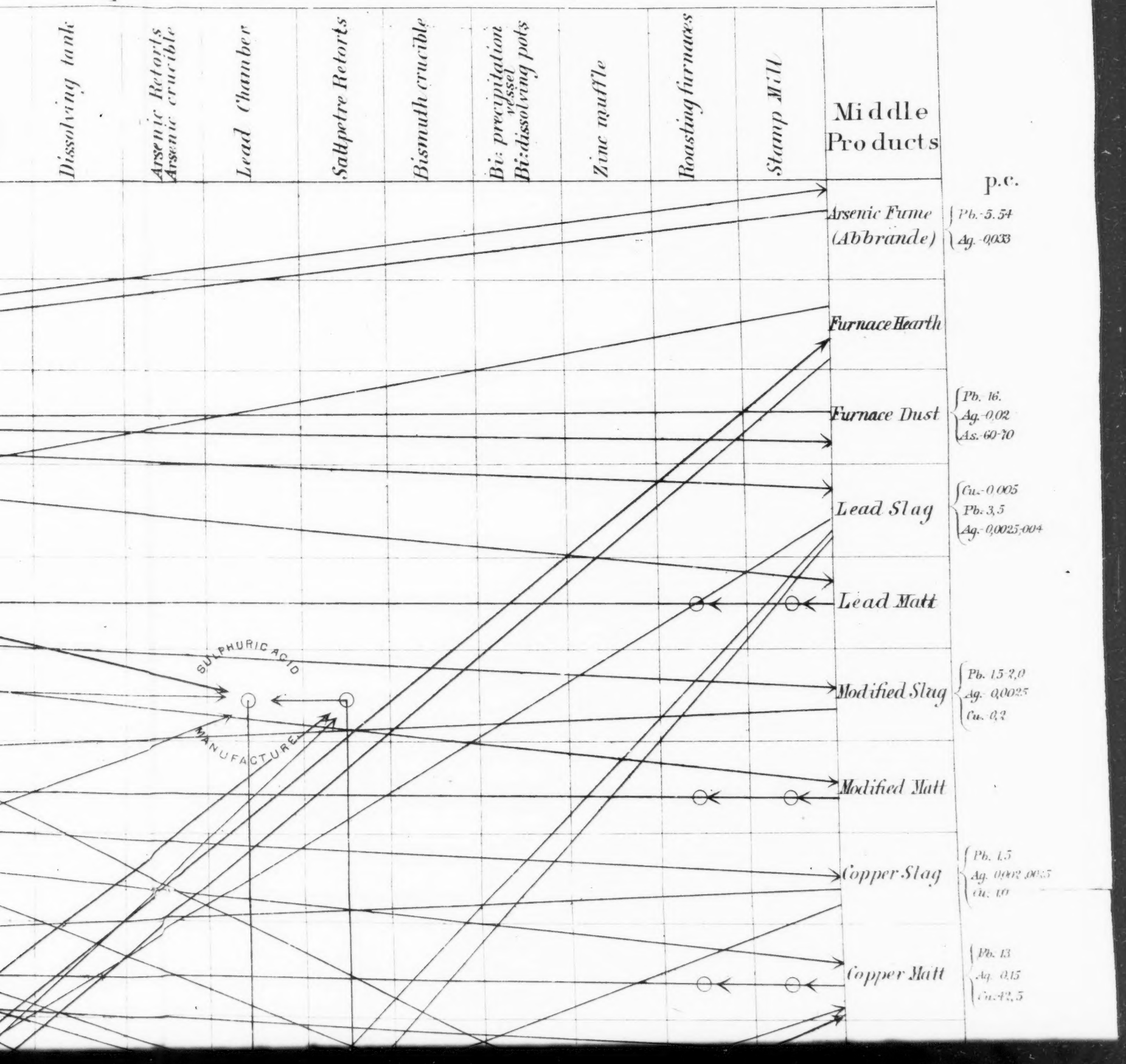
Separation kettle

Silver precipitation vessel



TING PROCESSES.

Philadelphia.
hiladelphia, June 17th 1870.



Copper

Flux Ores

Arsenious

Pyrito blendic

Silico-Pyritic

Silico blendopyr

Raw Matt

Bedaride of Iron

Heavy Spar

Fluor Spar

Lump ore

Quartz

Coke

Sulphur

Acid of Leadchum

Zinchlende

Arsenical Pyrites

Saltpetre

Lime

Hospec. Gu & less than 0.1 pc. Ag.

SPUR PROCESS.

CONCENTRATION PROCESS.

RAW PROCESS.

SPEISS PROCESS.

SPEISS CONCENTRATION PROCESS.

LEAD REFINING PROCESS.

LIQUATION

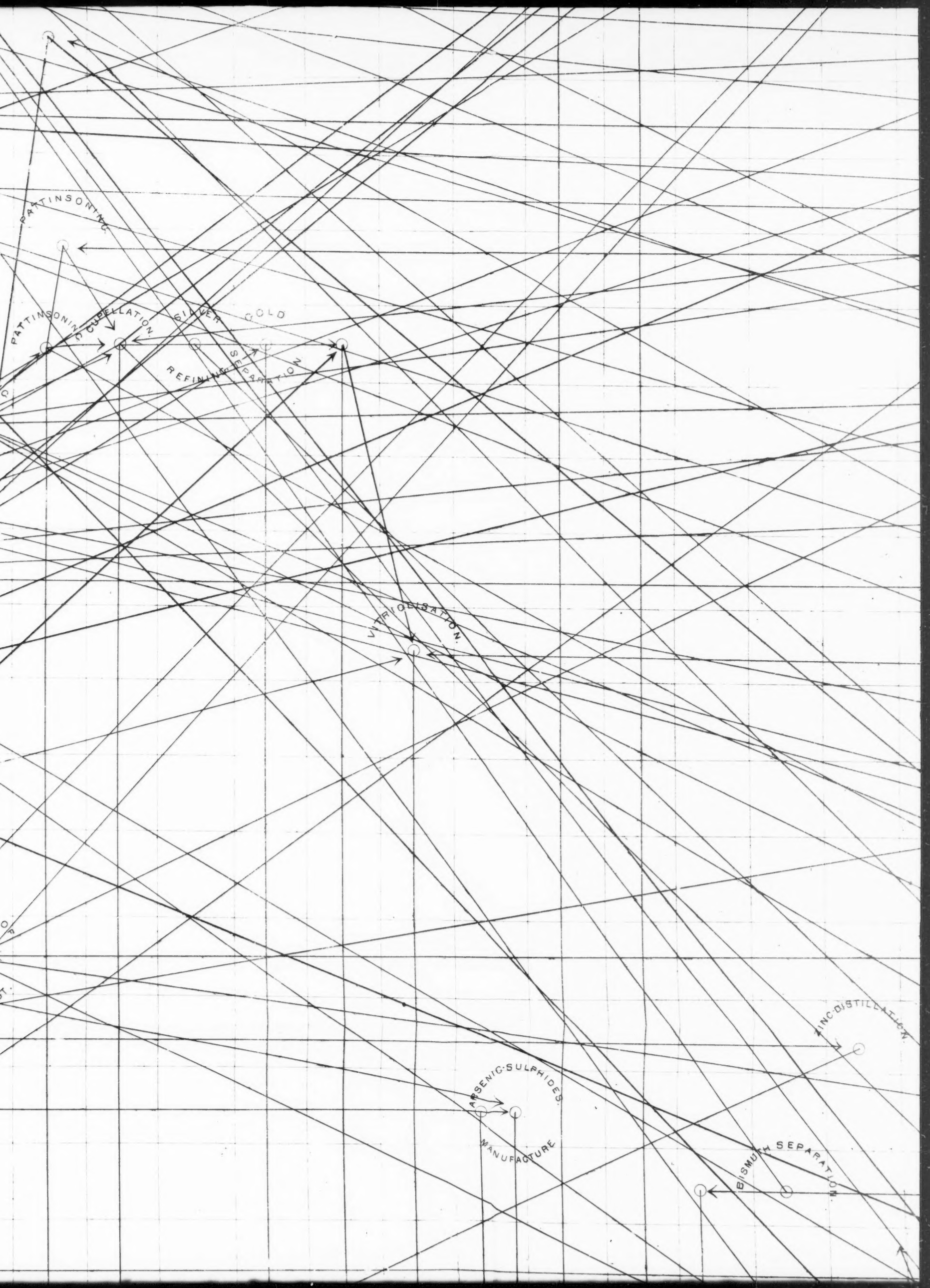
ABSTRICH FIRST.

LEAD SLAG

PROCESS ARSENIC

SUBLIMATION

LITHARGE


PATTINSONIZING
PATTINSONIZING
CUPELLATION
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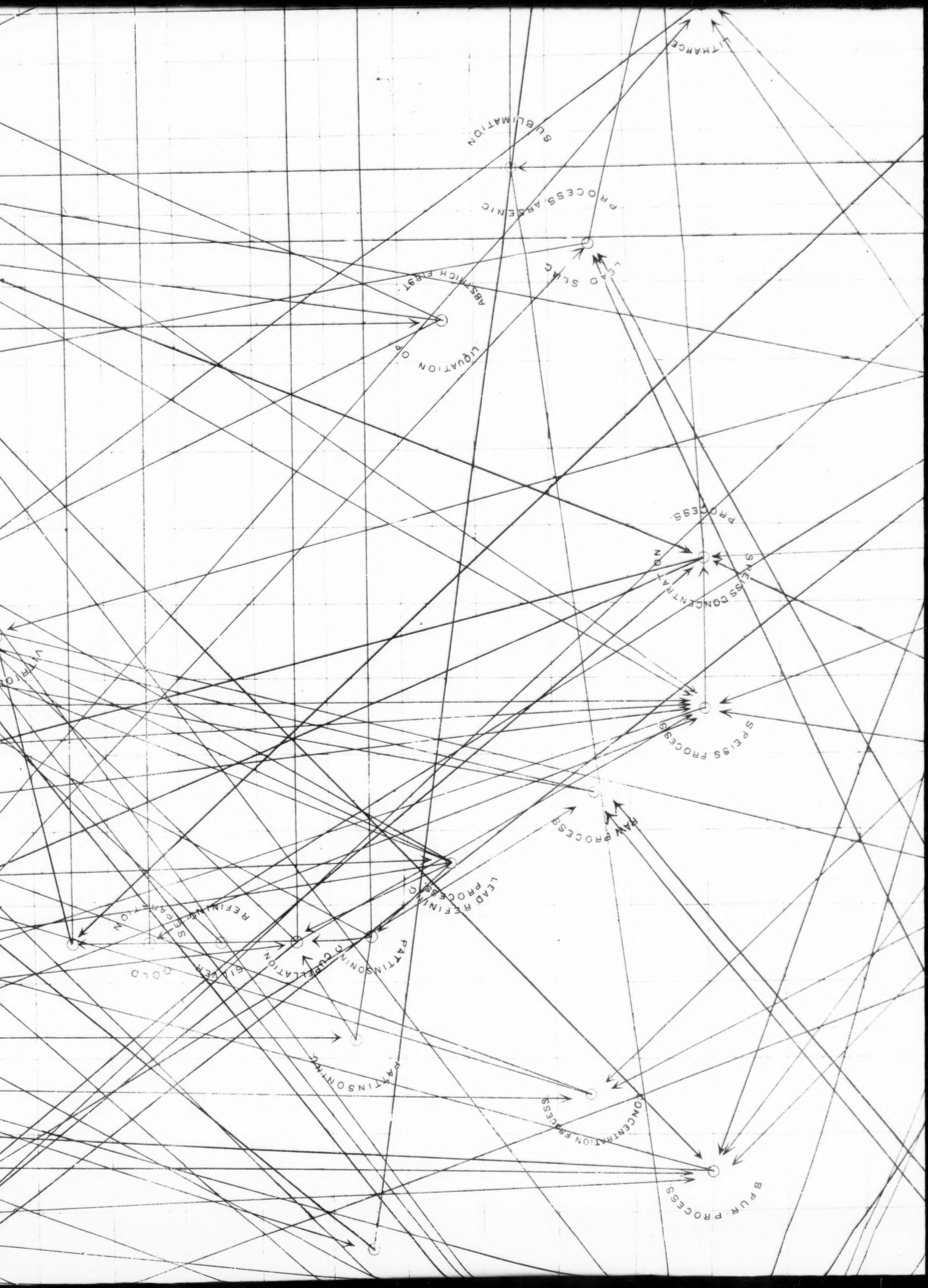
MANUFACTURE
ZINC DISTILLATION
BISMUTH SEPARATION


SULPHATE
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LIQUATION OF
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ZINC
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SPEISS PROCESS
RAW PROCESS
LEAD REFINING PROCESS
REFINING
SEPARATION
GOLD
SILVER
PATTINSONIZING
CUPELLATION
PATTINSON
CONCENTRATION PROCESS
BLUR PROCESS

Copper Slag — Pb. 1.5; Ag. 0.002-.0035

Copper Matt — Pb. 13; Ag. 0,15; Cu. 42,5

Spur Matt

Purified Lead

Raw Lead — Pb. 95.0; Ag. 0,60; Au. 0,17

Speiss — Ag. 0,4-0,5; Co.&Ni: 2,0 3,0; Cu. 12,0

Concentration Copper Slag — Pb. 13.0; Ag. 0,005; Cu. 3,0

Concentration Copper Matt — Pb. 6,0; Ag. 0,33 Au. 0,0005; Cu. 70,0

Raw Slag — Pb. 1,0; Ag. 0,0035; Cu. 13,0

Raw Matt — Pb. 5,0; Ag. 0,12; Cu. 13,0

Schlicker

1st Abstrich — As. 6,1; Sb. 14,3; Cu. 12.0

2nd Abstrich

3rd Abstrich

Bismuth Hearth — Pb. 23-27,0; Ag. 2,80; Bi. 17-40,0

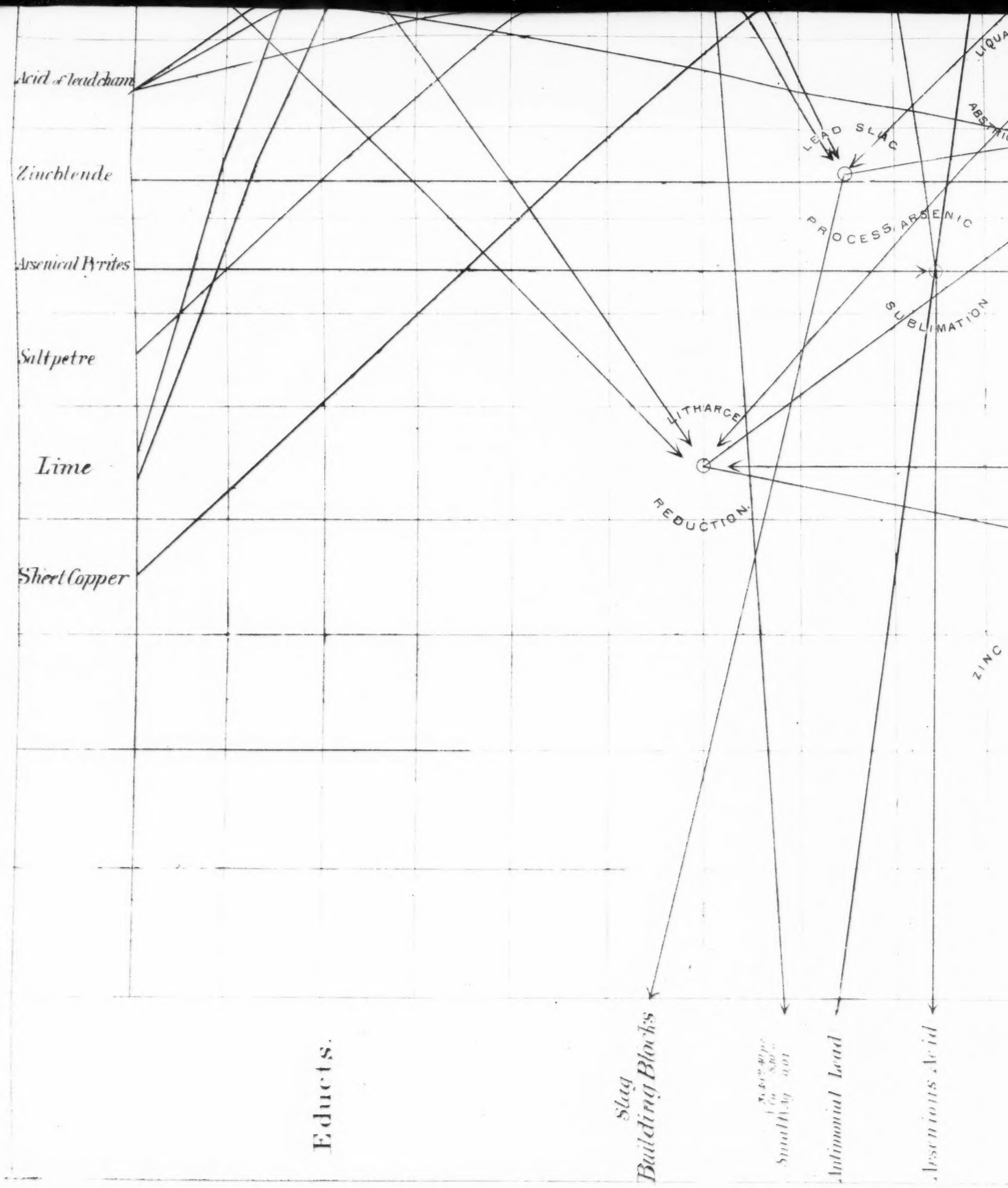
Litharge — Pb. 87,0

VITRIOLISATION

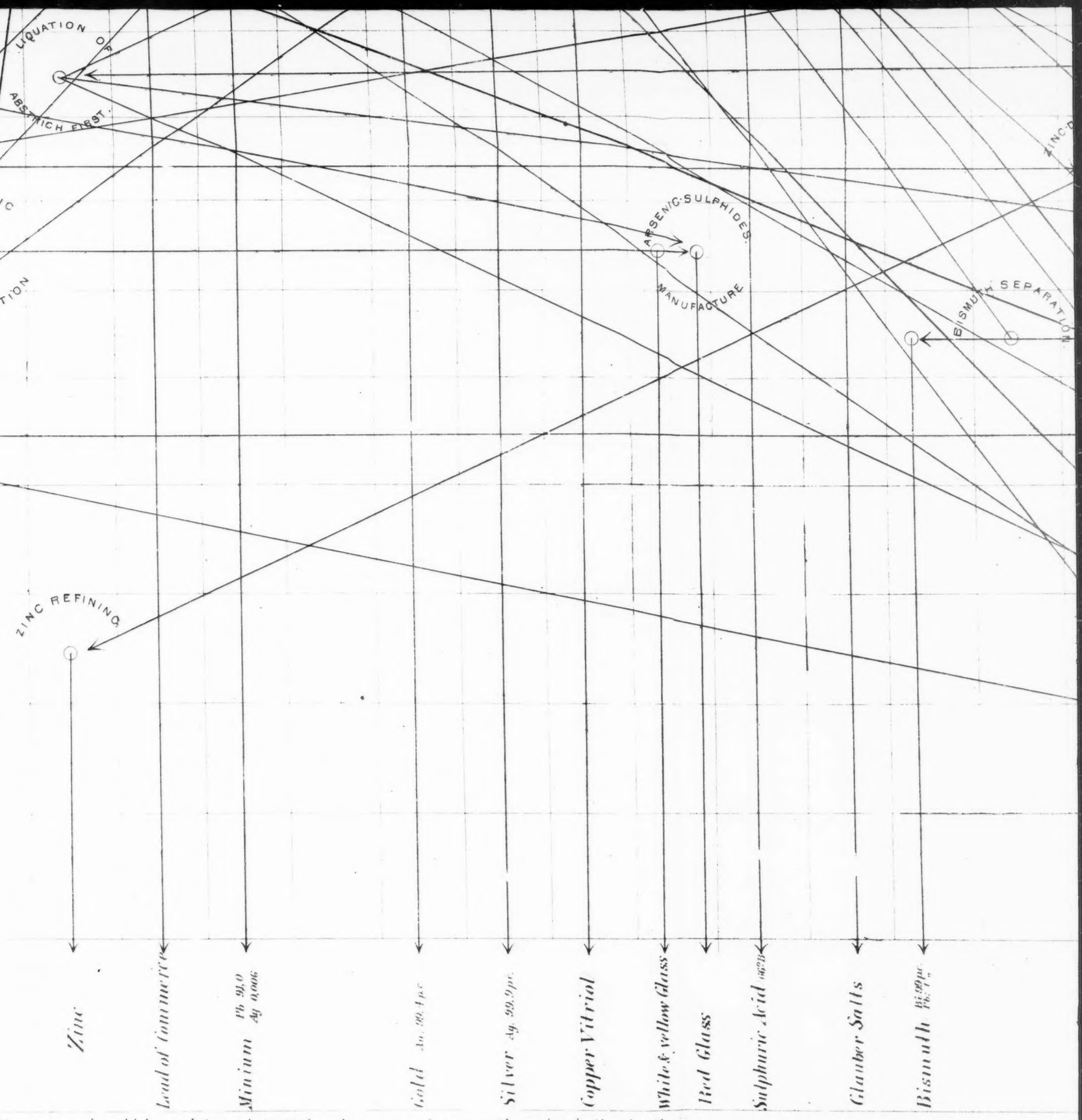
ARSENIC-SULPHIDES MANUFACTURE

ZINC-DISTILLATION

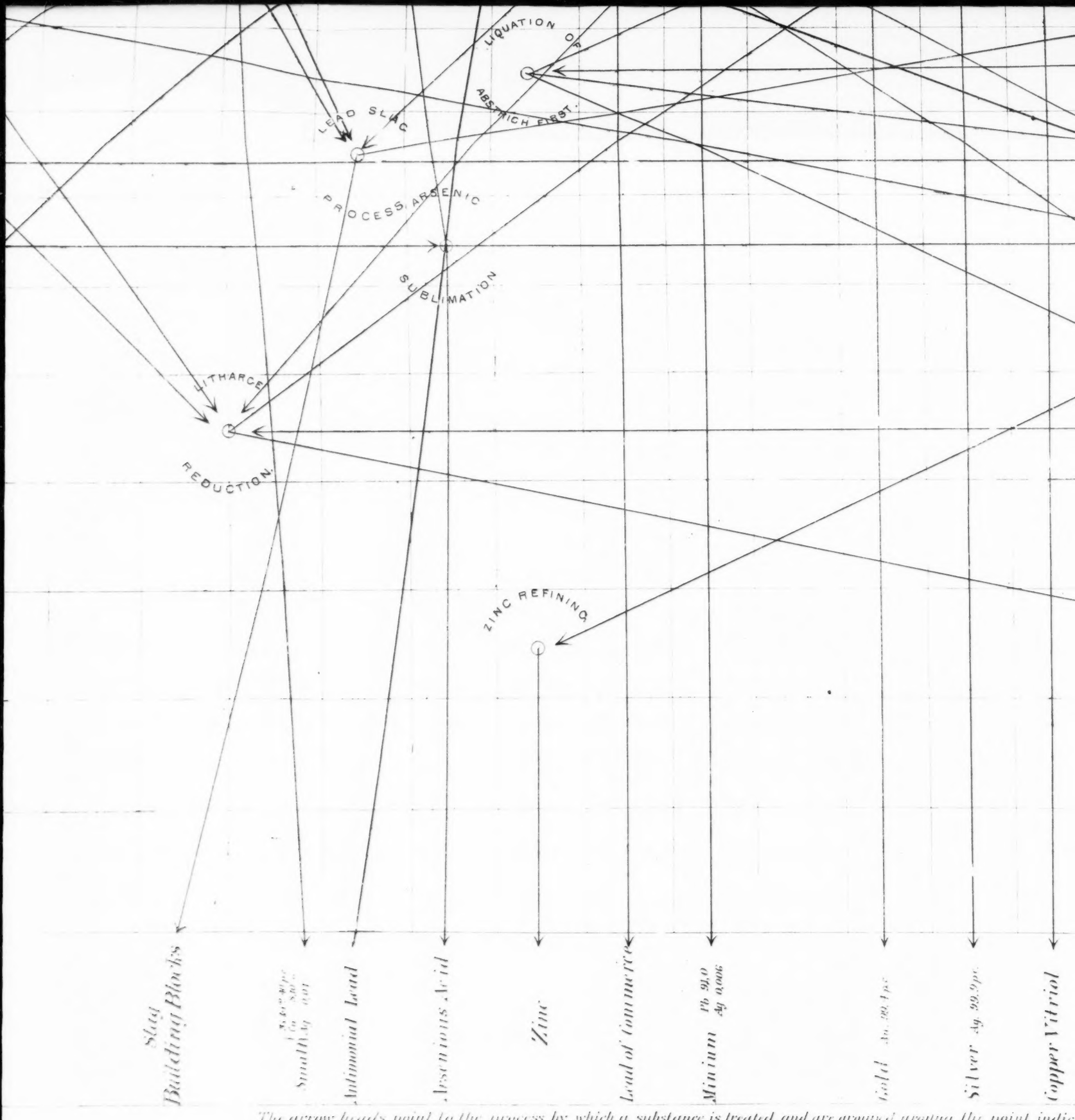
BISMUTH SEPARATION



The arrow heads point to the pro
The products of eac
Point



the process by which a substance is treated, and are grouped around the point indicating the process.
of each process are given in the lines drawn out from each centre.
Points on a line include the column on either side.



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The products of each process are given in the lines drawn out from each centre.
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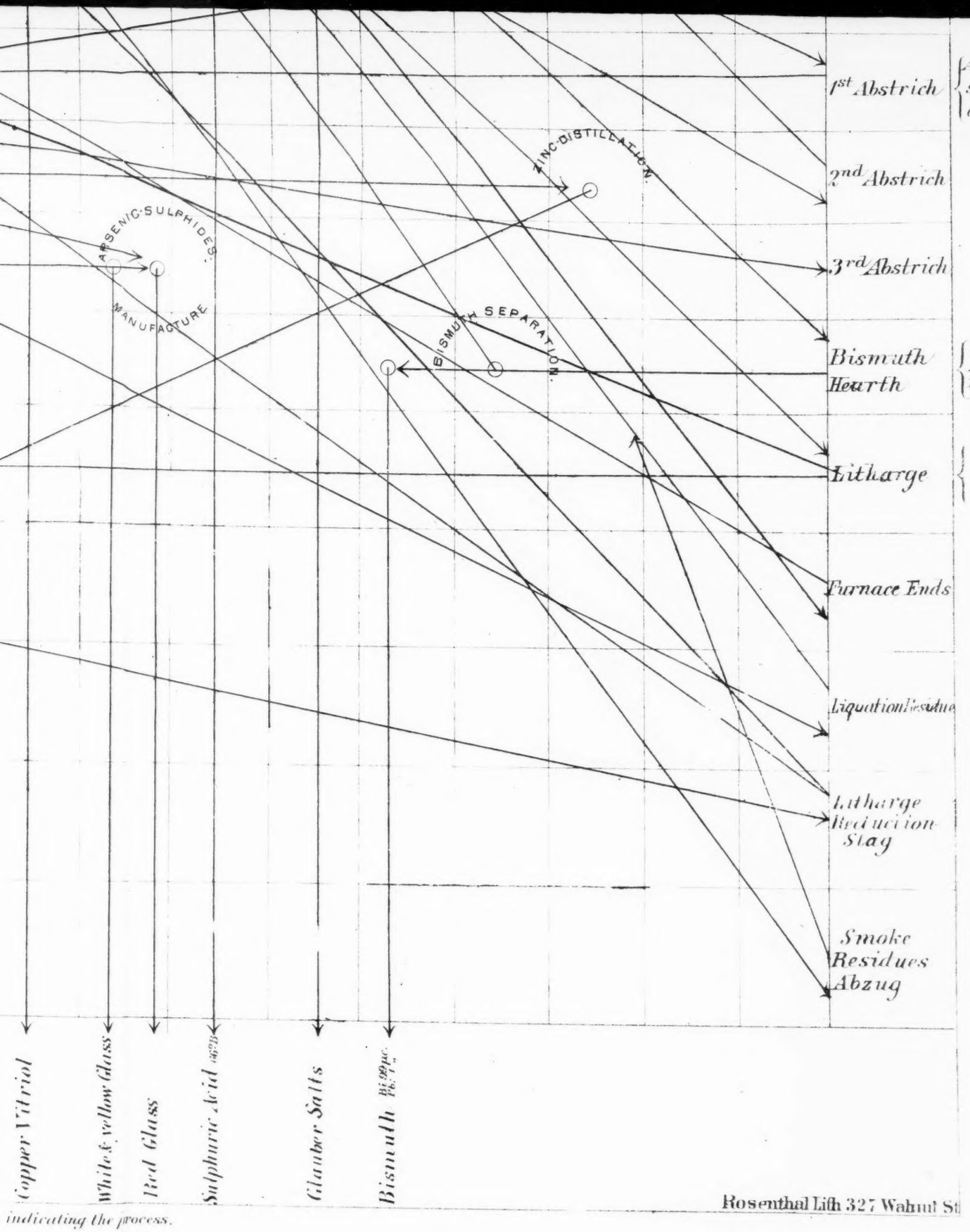

Rosenthal Lith 327 Walnut St

indicating the process.